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# Evaluation of PAT SAW 10c Portable Static Scales

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Technical Report

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13. ABSTRACT (*Maximum 200 words*)

U.S. Army Corps of Engineers Waterways Experiment Station conducted tests of weighing multiaxle vehicles using the PT SAW 10c portable static scales in both a loaded and half loaded condition on level and smooth surfaces. The tests were designed to determine the accuracy of the PAT scales. The equipment used during the test included four vehicles, two PAT SAW 10c scales, and wood leveling boards. The use of the Mississippi scales was necessary to determine the accuracy of the PAT scales. Each vehicle's axle was weighed 30 times. One special test was included to verify the axle height effect when the vehicles was weighed. The data was analyzed with frequency histograms, normal probability plots, and test of hypothesis.

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## SUMMARY

This report describes the results of the evaluation of PAT SAW 10 portable static scale. The field data was obtained weighing four representative vehicles on two scales, Mississippi scale (a part of a permanent weighing station), and PAT scale. The data was required to estimate the number of runs needed to obtain an accuracy of ±1 percent of the gross vehicle weight. The mean, standard deviation, variance, covariance, and confidence intervals were calculated for each sample. In addition, the ratio between the measured and true weight was obtained. The normability of the samples was verified by use of frequency histograms, and normal probability plot. As a result, an accuracy of 1 percent at a 95 percent confidence level can be obtained for the four test vehicles using the PAT scale. The accuracy can be obtained when the vehicles axles are at the same height. It was also found that the percents of error are greater for loaded vehicles than for the unloaded vehicles.

## PREFACE

The work reported herein was sponsored by the Defense Nuclear Agency (DNA) and was conducted at the Waterways Experiment Station (WES). This effort was performed with the support of the Pavement System Division's (PSD) Weigh-In-Motion (WIM) research program to weigh multiaxles vehicles using portable low profile axle scales.

The study was conducted at the U.S. Army Engineer Waterways Experiment Station under the general supervision of Dr. William F. Marcuson III, Director, Geotechnical Laboratory (GL), and under the direct supervision of Dr. George M. Hammitt II, Chief, Pavement System Division, and Dr. Albert J. Bush III, Chief, Criteria Development and Applications Branch (CDBA). The analysis and report was prepared by Ms. Rosa L. Santoni.

The WIM research program was directed by Dr. A. J. Bush, Chief, Criteria Development and Applications Branch, Mr. R. M. Bradley was the Principal Investigator, and Ms. R. L. Santoni was the co-investigator.

Dr. Robert W. Whalin was Director of WES during the preparation of this report. COL Bruce K. Howard, EN, was Commander.

# CONVERSION TABLE

Conversion factors for U.S. Customary to metric (SI) units of measurement.

| MULTIPLY → <br> TO GET ← | BY → <br> BY ← | TO GET <br> DIVIDE |
|---|---|---|
| angstrom | 1.000 000 x E -10 | meters (m) |
| atmosphere (normal) | 1.013 25 x E +2 | kilo pascal (kPa) |
| bar | 1.000 000 x E +2 | kilo pascal (kPa) |
| barn | 1.000 000 x E -28 | meter$^2$ (m2) |
| British thermal unit (thermochemical) | 1.054 350 x E +3 | joule (J) |
| calorie (thermochemical) | 4.184 000 | joule (J) |
| cal (thermochemical/cm$^2$) | 4.184 000 x E -2 | mega joule/m$^2$(MJ/m$^2$) |
| curie | 3.700 000 x E +1 | * giga becquerel (GBq) |
| degree (angle) | 1.745 329 x E -2 | radian (rad) |
| degree Fahrenheit | $\tau_K$=(t°f+4.59.67)/1.8 | degree kelvin (K) |
| electron volt | 1.602 19 x E -19 | joule (J) |
| erg | 1.000 000 x E -7 | joule (J) |
| erg/second | 1.000 000 x E -7 | watt (W) |
| foot | 3.048 000 x E -1 | meter (m) |
| foot-pound-force | 1.355 818 | joule (J) |
| gallon (U.S. liquid) | 3.785 412 x E -3 | meter$^3$ (m$^3$) |
| inch | 2.540 000 x E -2 | meter (m) |
| jerk | 1.000 000 x E +9 | joule (J) |
| joule/kilogram (J/kg) radiation dose absorbed | 1.000 000 | Gray (Gy) |
| kilotons | 4.183 | terajoules |
| kip (1000 lbf) | 4.448 222 x E +3 | newton (N) |
| kip/inch$^2$ (ksi) | 6.894 757 x E +3 | kilo pascal (kPa) |
| ktap | 1.000 000 x E +2 | newton-second/m$^2$ (N-s/m$^2$) |
| micron | 1.000 000 x E -6 | meter (m) |
| mil | 2.540 000 x E -5 | meter (m) |
| mile (international) | 1.609 344 x E +3 | meter (m) |
| ounce | 2.834 952 x E -2 | kilogram (kg) |
| pound-force (lbs avoirdupois) | 4.448 222 | newton (N) |
| pound-force inch | 1.129 848 x E -1 | newton-meter (N.m) |
| pound-force/inch | 1.751 268 x E -2 | newton/meter (N/m) |
| pound-force/foot$^2$ | 4.788 026 x E -2 | kilo pascal (kPa) |
| pound-force/inch$^2$ (psi) | 6.894 757 | kilo pascal (kPa) |
| pound-mass (lbs avoirdupois) | 4.535 924 x E -1 | kilogram (kg) |
| pound-mass-foot$^2$ (moment of inertia) | 4.214 011 x E -2 | kilogram-meter$^2$ (kg.m$^2$) |
| pound-mass/foot$^3$ | 1.601 846 x E +1 | kilogram/meter$^3$ (kg/m$^3$) |
| rad (radiation dose absorbed) | 1.000 000 x E -2 | **Gray (Gy) |
| roentgen | 2.579 760 x E -4 | coulomb/kilogram (C/kg) |
| shake | 1.000 000 x E -8 | second (s) |
| slug | 1.459 390 x E +1 | kilogram (kg) |
| torr (mm Hg, 0°C) | 1.333 22 x E -1 | kilo pascal (kPa) |

*The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (Gy) is the SI unit of absorbed radiation.

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# SECTION 1

# INTRODUCTION

## 1.1 GENERAL.

This is a summary report of tests conducted at Waterways Experiment Station (WES) during the period June 23 to 25, 1992, on portable static wheel load scales acquired from PAT Equipment Corporation of Chambersburg, PA. A description of the test methodology and the analytical approach utilized to evaluate the data sets gathered in the field are included in this report. Common field problems that were encountered during the collection of the data and recommendations for future measurements and analysis of data are also provided.

The portable wheel load scales that were used were PAT MODEL SAW 10c scales. The PAT MODEL SAW 10c scale is a compact lightweight scale used for measurements of wheel load weights up to 20,000 lb or single axle weights up to 40,000 lb. For single axle weighing, two of the wheel load scales were connected by a standard 15-foot cable. When connected, the scales automatically sum the wheel weight for an axle load and allow for the observation of the single axle weight on either side of the test vehicle. The scale can be used on any normal road surface without special precautions, as indicated in the Technical Description and Operating Manual supplied with the scales. However, it is necessary to compensate for the height of the scales by placing dummy plates or ramps under the tires of the other vehicle axles to ensure all tires are at the same height as the weighing surface.

All of the tests were performed on a resin modified asphalt test section located adjacent to the Geotechnical Laboratory at WES. The pavement section provided a flat even surface on which test could be performed. Four vehicles were used with different numbers of axles: Jeep utility pickup truck - 2 axles, military transport (AT6X6) - 3 axles, GMC heavy equipment mobile transport truck - 4 axles, and 18 wheel tractor-trailer (3S2) - 5 axles. The parameters recorded in the field were temperature, time, date, weather conditions, number of axles per vehicle, tire pressure, driver's weight, and axle weight. The true weight of the vehicles was obtained using the Mississippi Department of Transportation (DOT) platform scales located on Interstate 20 east of Vicksburg.

The analysis of the data collected during this test series includes the calculation of statistical parameters such as mean, standard deviation, and percent of error. Some statistical inference using a test of hypotheses was performed by comparing the sample (axle weight of the individual trucks) to the total population (axle weights of all the vehicles).

## 1.2 PURPOSE.

The objective of the test was to estimate the number of tests that were required to determine if the portable static scales manufactured by PAT were capable of weighing multiaxle vehicles, over a wide range of loads, to an accuracy of ±1 percent of the gross vehicle weight.

## 1.3 SCOPE.

The test included the use of two scales, the PAT and the Mississippi DOT scale. The Mississippi DOT scale was assumed 100 percent accurate to evaluate the PAT scale accuracy. The field test included the weight of the vehicle axle using the PAT scales and total vehicle weight using the Mississippi DOT scale on a level and smooth surface. The sum of all the axles was considered as the total vehicle weight (or the sample weight) when the PAT scale was used. In addition, the possible vehicle weight difference caused by the fuel consumption was assumed insignificant. The number of observations gathered in the field was 30 for each vehicle axle using the PAT scale and 2 for each vehicle using the Mississippi scale. Four vehicles were used to represent the vehicle population of 2, 3, 4, and 5 axles. The vehicles were weighted with a load and then with half of that load. These samples were used to represent the vehicle weight population. This test was developed using the analysis and results of data acquired from a previous test conducted at WES on May 21 to 22, 1992, as a reference. The use of data collected from the previous test helped to avoid possible errors and solve logistic problems that occurred in the field. The statistical analysis included the normability assumption, the determination of a confidence interval that the results would be within ± 1 percent of the true gross vehicle weight, the determination of the number of runs needed to obtain 99 percent accuracy in the results, the calculation of the samples parameter such as mean, variance, standard deviation, coefficient of variation, percent of error, and test of hypothesis.

## SECTION 2

## PREVIOUS TESTS

### 2.1 TEST SUMMARY.

A previous test was performed at WES in May of 1992. The test purposes were to familiarize with the PAT scale use and setup, and to evaluate if the PAT scale replicability can changed with the weighing direction (north or south). Data for the test were obtained by passing test vehicles over the scales in two directions (north and south). However, only ten runs were collected for each vehicle in that test. The weight of the axle loads was calculated by averaging the individual wheel loads for the two directions. The results of the analysis of the data and the conclusions of the test can be found in Appendix A. The test results were used to design the test conducted in July 23-25, 1992 which evaluated the scales accuracy. The statistical analysis of the data shows that there is no significant difference between the data collected from the two directions (north and south). Assuming a level straight approach, the vehicles need only be weighed in one direction to save time in obtaining the data that represent the whole population.

The classification of the statistical size of the sample for each of the vehicles was a small sample since the number of samples taken was less than 30. Therefore, a small sample theory was used for the analysis. One significant result found was that the sample for each of the vehicles does not represent the entire population. This problem implies that the conclusions and recommendations that can be made using these samples were not reliable. The samples reliability were needed to estimate the number of tests that were required to determine if the portable static scales were capable of weighing multiaxle vehicles to an accuracy of ±1 percent of the gross vehicle weight.

### 2.2 STATISTICAL APPROACH.

To determine the number of tests required to achieve an accuracy of 1 percent, 2 percent, and 3 percent, a confidence level of 95 percent was selected. Equation 2.1 was used to calculate the number of observations, but instead of $Z_{\frac{\alpha}{2}}$ (for normal distribution, $n \geq 30$), the small sample distribution t was used in the previous test (Montgomery 1980, and Walpole and Myers 1972).

$$n = \left[\frac{Z_{\frac{\alpha}{2}}\,\sigma}{e}\right]^2 \qquad (2.1)$$

where

$n$ = sample size
$Z_{\frac{\alpha}{2}}$ = critical value or confidence coefficient
$\sigma$ = standard deviation
$e$ = error

This formula is applicable only if the deviation ($\sigma$) of the weight with respect to the average weight is known (population's variance). The lack of variance requires a preliminary sample to represent the population. A good representation of the population is found if the sample mean is equal to the population mean. Also, histograms and normal probability plots can be used to prove the normal condition of the samples. It was determined that the previous test did not meet this condition and the possible conclusions or recommendations based on this sample would be in error.

# SECTION 3

# DESCRIPTION OF THE TEST

## 3.1 GENERAL INFORMATION.

The weight data gathered in the field was accompanied by other general information which included date, time, atmospheric conditions, temperature, tire pressure, type of vehicle, number of axles, and load (the vehicle and driver's weight). This information helps to explain some of the abnormal conditions or problems that can be found in the data. The information will also be relevant for future analysis of the data. In general, the conditions during the test were similar, sunny and humid in the morning and very hot in the afternoon with temperatures exceeding 100°F. Four vehicles were used with different numbers of axles: Jeep utility pickup truck - 2 axles, military transport (AT6X6) - 3 axles, GMC heavy equipment mobile transport truck - 4 axles, and 18 wheel tractor-trailer (3S2) - 5 axles (see Figures 3-1 to 3-4). The tire pressures and the loads in the vehicles varied with the type of test vehicle. The measurements were divided into two parts as the vehicles were weighed first fully loaded and then at half of its original load. The loads in the vehicles consisted of blocks of lead and steel equivalent to 2,000 and 1,000 lb, respectively ( see Table 3-1). The jeep was loaded with one block of steel, the AT6X6 with 8 lead blocks, the GMC with 16 lead blocks and the 3S2 with 16 lead blocks. The unloaded case consisted of a reduction to half the previous load. Appendix C shows the maximum and minimum weight for each axle of the vehicle. In addition, Table 3-2 shows the total weight of the vehicles for the load and unload cases; a range of minimum and maximum load occurred due to fluctuations in the Mississippi's platform scale. One special test was included to verify the axle height effect when the vehicles were weighed. The sample size for this test was 15 observations for unloaded and loaded conditions and the vehicle differs in height with respect to the scales. Only the adjacent axles to the scale had the same height as the scales. The vehicle used for this test was the GMC truck and the results were represented along the report by $GMC_s$. When all axles were blocked (30 runs) the notation used to represent the results was GMC.

Table 3-1. Vehicle weight conditions.

| VEHICLE | LOADED lb | UNLOADED lb | BLOCK |
|---|---|---|---|
| Jeep | 1,000 | 0 | Steel |
| AT6X6 | 16,000 | 8,000 | Lead |
| GMC | 32,000 | 16,000 | Lead |
| 3S2 | 32,000 | 16,000 | Lead |

Table 3-2. Total vehicle weight using PAT scales.

| VEHICLE | LOAD, lb | | UNLOAD, lb | |
|---|---|---|---|---|
| | MAXIMUM | MINIMUM | MAXIMUM | MINIMUM |
| JEEP | 5,240 | 5,160 | 4,220 | 4,140 |
| AT6X6 | 35,720 | 34,900 | 27,540 | 26,820 |
| GMC[1] | 80,880 | 79,660 | 64,640 | 64,200 |
| $GMC_S$[2] | 80,460 | 79,300 | 64,100 | 63,560 |
| 3S2 | 70,560 | 68,960 | 53,660 | 52,540 |

[1] All axles were blocked (30 runs)

[2] Only axles adjacent to the scale were blocked (15 runs)

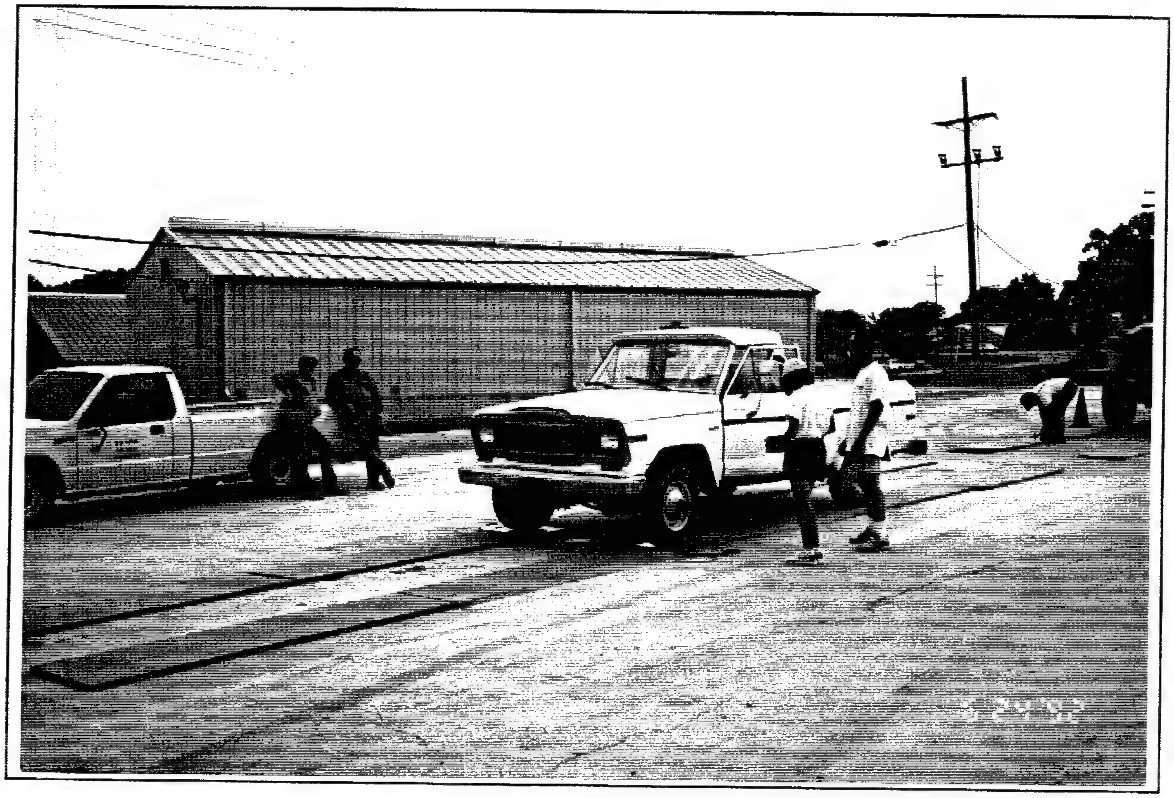

Figure 3-1. Jeep pickup truck, 2 axles.

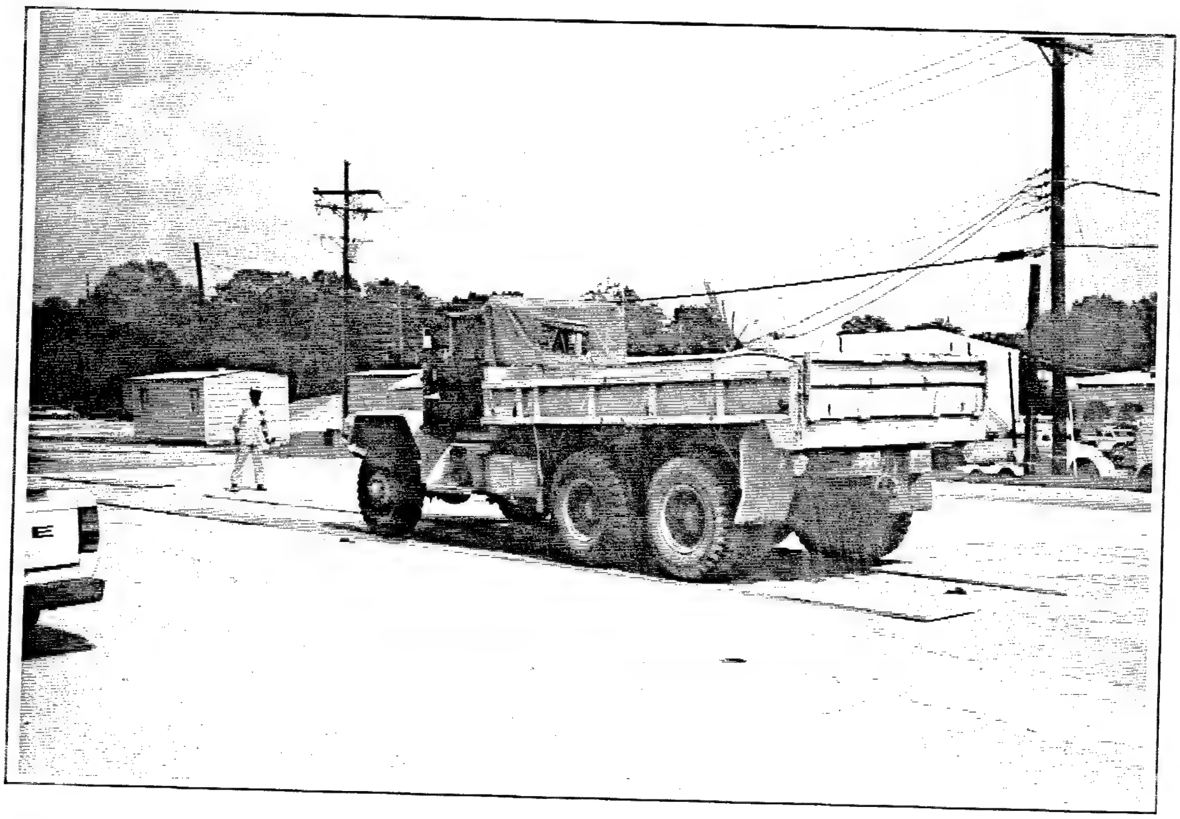

Figure 3-2. Military transport truck (AT6X6), 3 axles.

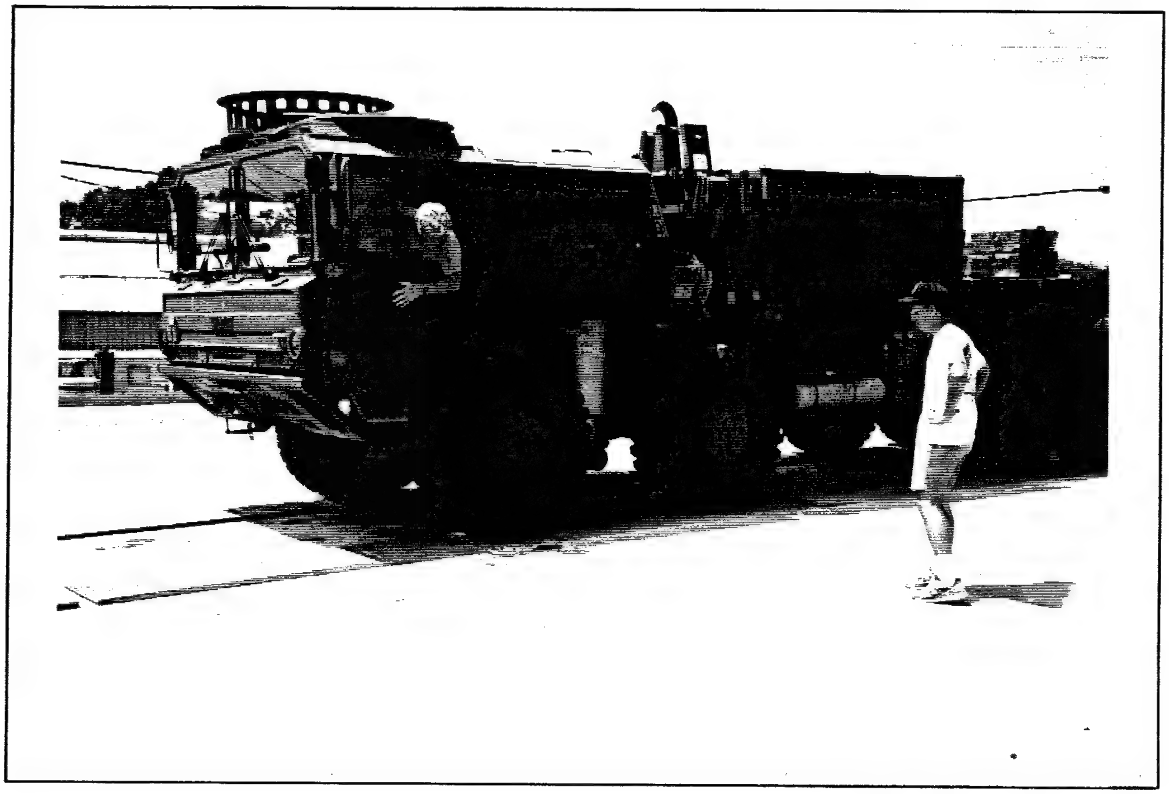

Figure 3-3. GMC transport truck, 4 axles.

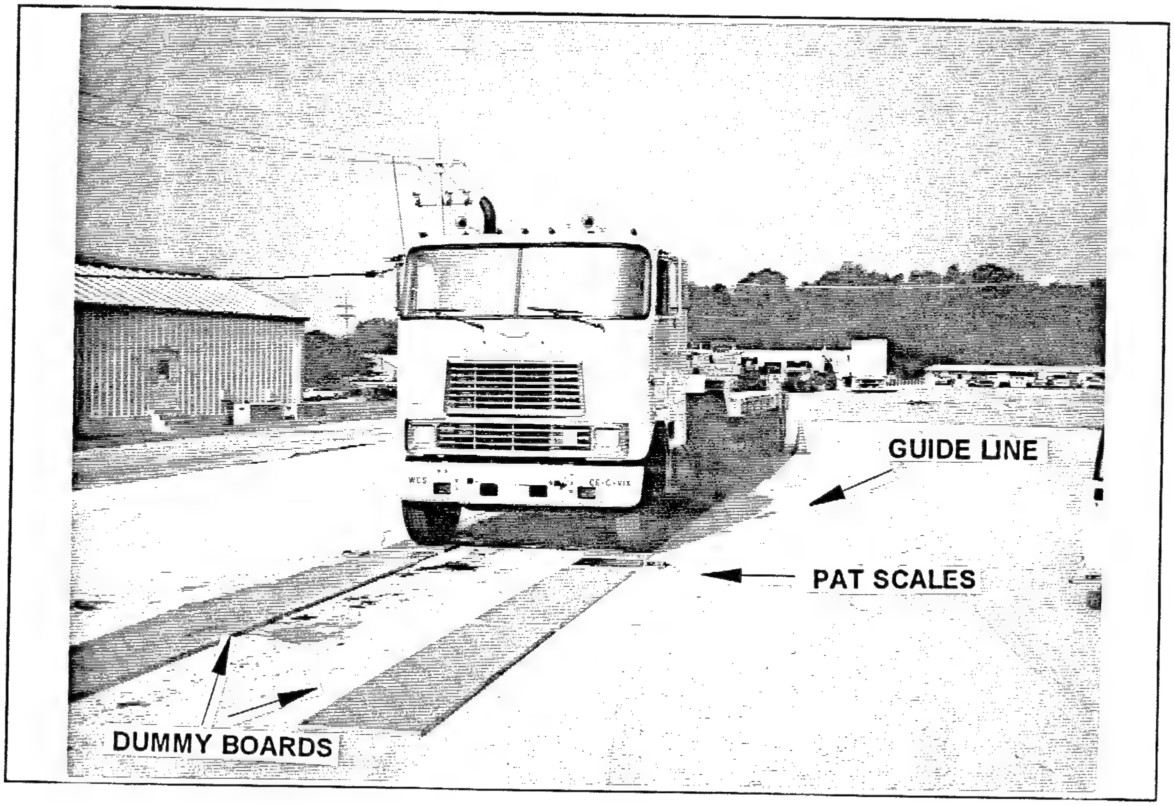


Figure 3-4. Tractor trailer truck (3S2), 5 axles.

## 3.2 PROCEDURE.

Testing procedures were clearly defined and important warnings were specified to avoid error in data collection. Some of these included: the load in the vehicle should remain in the same place during the entire testing procedure, the area where the scale is placed should be clean and level, the height of all of the wheels of the vehicle should be at the same height as the scale, and the tires should be centered on the scale during testing.

The correct operation of the scales and the charge of the scale's batteries were checked each day before tests began. The test area was cleaned and guides were painted on the test surface to help drivers maintain vehicle alignment and position. The fuel in the trucks and tire pressures were verified each morning. Special forms to record data for each type of vehicle were developed which helped to better organize the data (see Appendix B). The order in which the vehicles were weighed was random but the first sample for each vehicle was for the loaded condition. The number of runs for each vehicle was 30 for each loading condition (loaded and unloaded). In addition, to compensate for the scale height, leveling boards were used. Another 15 runs were taken for the GMC truck for the loaded and unloaded condition with leveling boards placed only under the axle adjacent to the scale (the scale height was not compensated). The test was completed in three days, starting at 7:00 am and at 5:30 pm. The schedule for the third day was from 7:00 am to 12:00 pm.

## 3.3 WEIGHT OF THE VEHICLES.

All of the trucks were weighed at the beginning of the first set of samples (loaded and half-loaded) on the Mississippi Scales. The Mississippi scales are located on the east- and west-bound lanes of Interstate 20 at Vicksburg, and the scales are part of a permanent weigh station (see Figure 3-5). The average weight from both scales was used as the true weight of the vehicle (or gross vehicle weight). The weigh station consists of a Weigh-In-Motion (WIM) system that can weigh vehicles without traffic interruption and static scales. The static scale involves bending plate technology and its objective is to make accurate measurements of vehicle weights. The individual axle loads, as well as the total weight of the vehicle, are calculated. Vehicles which are detected as being outside the load limits are directed to the static scale where a precise check is made. Those within the load limits may proceed on their journeys without additional interruption. For the purpose of this investigation, the weight information of the Mississippi static scale was only considered.

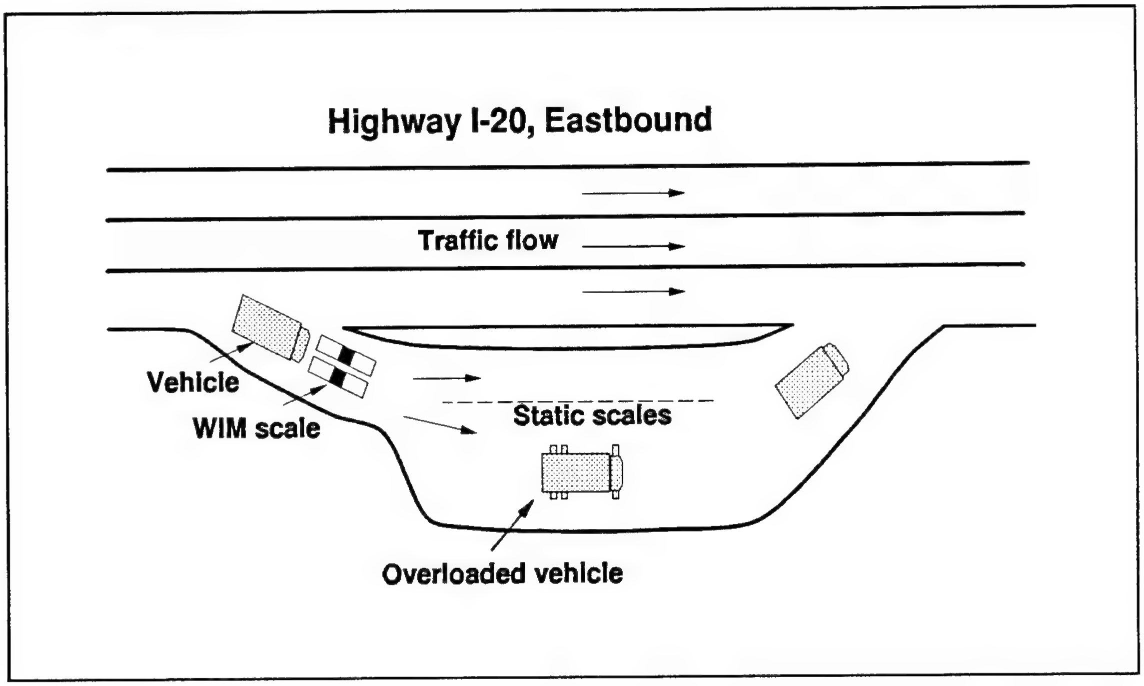


Figure 3-5. Mississippi permanent weigh station layout.

Figure 3-6 shows the placement of leveling boards when the number of axles increase. Figure 3-7 shows the position of the PAT portable static scales and the leveling boards on the test section. It is important to note that the Technical Description and Operating Manual provided with the PAT scale shows a different layout for the leveling boards. The positioning of the boards recommended in the manual gave good results for light and non-articulated vehicles. On the articulated vehicle (3S2) it was difficult to keep the vehicle in alignment and position as the vehicle was moving across the scale. In other cases, it is difficult to maintain the trucks in position because the individual leveling boards had a tendency to creep as the driver applied power to position the vehicle over the leveling boards. In addition, the scale manual indicates that leveling boards should be used in all cases for height compensation when the number of sets of scales is less than the number of axles. This implies that the board position should not affect the results. Before starting the test, several runs with the leveling boards placed in the standard configuration were examined. These were then compared with runs using leveling boards in the wide position; no differences were found between the weights.

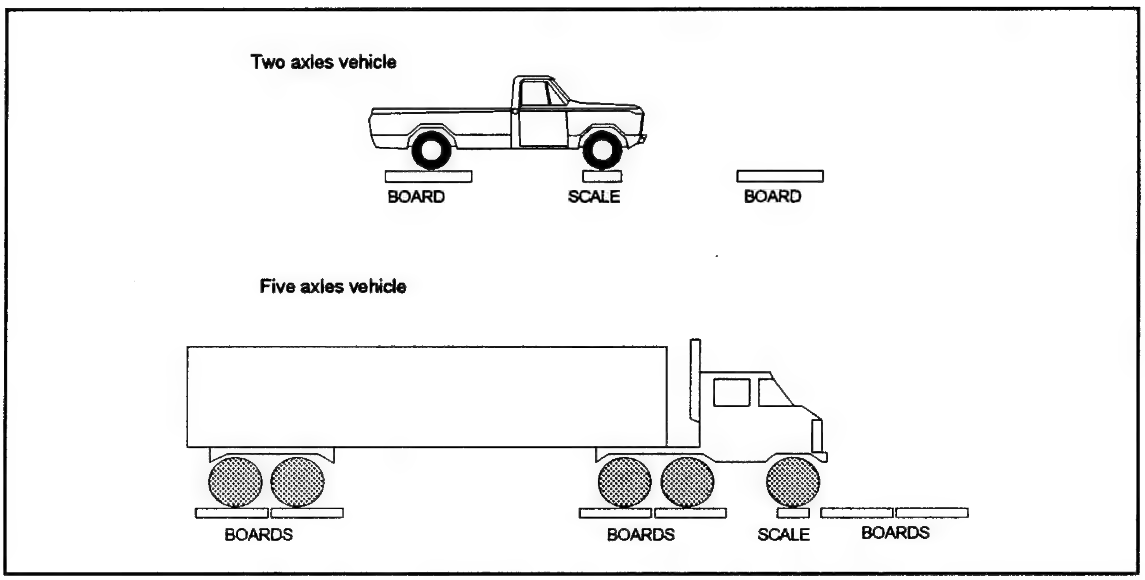


Figure 3-6. Placement of leveling boards as the axles increase.

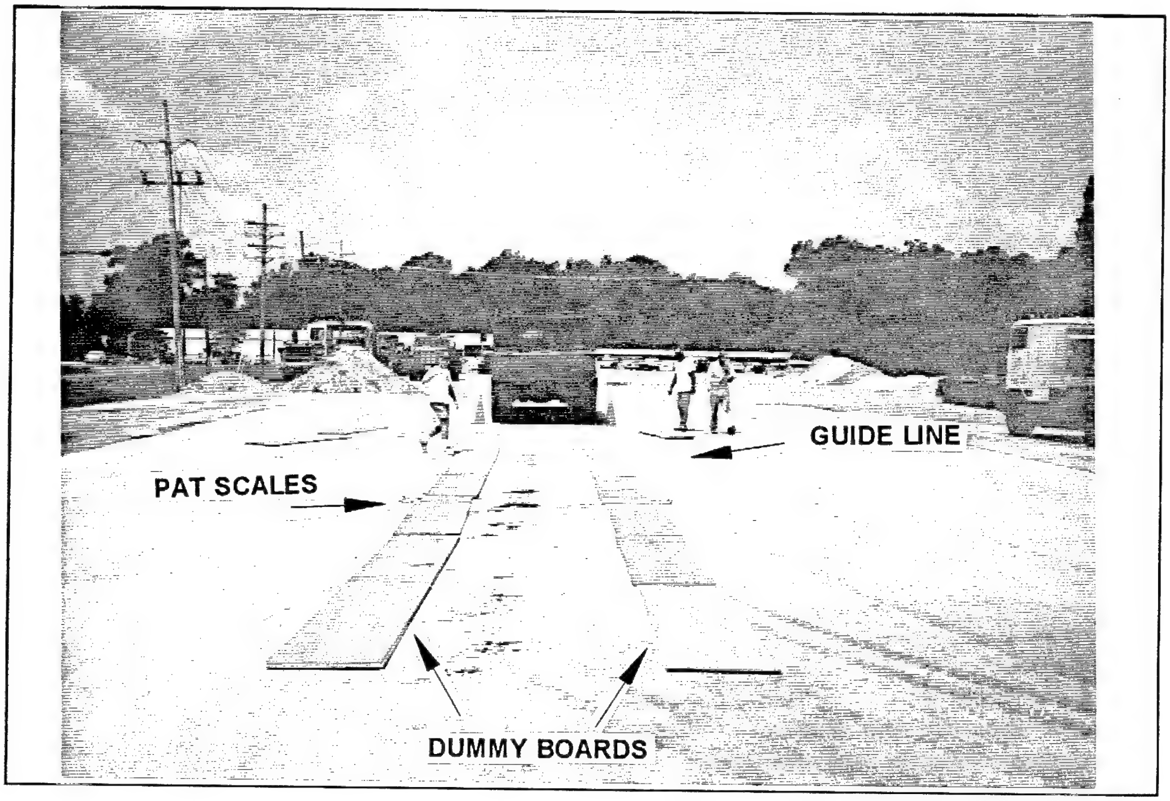


Figure 3-7. Scales and board positions.

Initially, the driver would pull up and place the first axle of the vehicle on the center of the scale. Positions were then marked for leveling board placement for the remaining axles. This procedure was followed for each vehicle, ensuring correct placement of leveling boards for each run. Testing for the Jeep went relatively quickly as it had only two axles that could easily be positioned over the scales. The GMC and AT6X6 trucks took more time as they were more difficult to align and center over the scales. These three vehicles were then moved forward and backward across the scales and leveling boards, stopping to obtain each axle's weight for each run. If the alignment of the vehicles was not perpendicular to the direction of travel, the readings were stopped, the vehicles realigned, and measurement retaken. If the 3S2 truck was not correctly aligned for the measurement, weighing was suspended and the vehicle was required to make another pass due to the difficulty in backing the vehicle over the scales. In addition, the driver needed more time to align the cab and the trailer with the scales.

## SECTION 4

## PROBLEMS IN THE FIELD

### 4.1 MECHANICAL PROBLEMS.

Some mechanical problems were encountered in the field at the beginning of the test and also during the test. The 3S2 truck was chosen to start the test but encountered some mechanical problems. The 3S2 truck brake system was not working properly. As a result, this situation caused wrong weigh reading because the truck could not be stopped in the right place. The PAT scales accuracy was affected and the number of runs increased by this condition.

Mechanical problems on a multiaxle vehicle affected the PAT scale measures, and the results could show erroneous conclusion on that vehicle type. The use of PAT scales for multiaxle vehicle could be questionable but caution and care were the main tool to detect and avoid possible error in the weighing process. The Jeep was then substituted as the lead test vehicle and the 3S2 was repaired.

### 4.2 EQUIPMENT PROBLEMS.

The leveling boards consisted of two wooden panels 1 inch and 1/2 inch in thickness. These boards were used as dummy plates to raise adjacent axles to the PAT scales in order to obtain a level surface with the PAT scale, thus all the wheels of the vehicle were at the same height. The two panels however, had a tendency to slide apart and the entire assembly would move across the concrete surface. To fix the problem, the panels were nailed together. The problem still remained because the weight of the vehicle caused the sections to separate and move. To minimize the movement between the leveling boards and the concrete surface, the vehicles were required to approach the leveling boards at a very low speed. These conditions were also observed when the vehicle's brakes were applied. Also observed during the tests were deflections in the leveling boards due to applied load, as well as cracking of the edges.

The Technical Description and Operating Manual warning about the positioning of the boards to keep the vehicle in alignment and position as it is moving across the scale to avoid weighing errors. In addition, the scale manual indicates that leveling boards should be used in all cases for height compensation when the number of sets of scales is less than the number of axles to avoid difference in the measurements. The correct placement of the axles over the scale was affected by the tendency of the leveling board to slide apart. The alignment of the vehicles needed to be perpendicular to the direction of travel to obtain accurate weighing. When the run did not accomplished with this requirement, the vehicle was required to make another pass. The tendency to slide apart of the leveling boards, and it movements across the surface implied additional time to align the cab and the trailer with the scales, increase the number of wrong runs, and lack of accuracy of the scales.

# SECTION 5

# ANALYSIS OF THE DATA

## 5.1 FIELD ANALYSIS.

For each run, the data were recorded and analyzed to detect if significant differences were observed from run to run. If the value between the runs was significantly different, the positioning and the alignment of the vehicle were checked.

## 5.2 STATISTICAL ANALYSIS.

### 5.2.1 Parameter.

The population of interest in this test was the total weight of the vehicle, which is the sum of all individual axles weighted. Two different samples of 30 runs were gathered for each vehicle type. The first set of data applies to the truck loaded and the second set applies to the vehicle at half of the original load. The mean, standard deviation, variance, and percent of the error between the true weight and the observed weight were calculated for each sample (e.g., Dixon and Massey 1957 and Spiegel 1961). See Appendix C. Tables 5-1 and 5-2 show the summary of these parameters for the loaded and unloaded conditions. The errors between the means are small, which indicates that the sample has similar characteristics to the population. Thus, the PAT shows precision in its measurements.

The error for the regular GMC tests and the separate GMC tests (in which only axles adjacent to the weighed axle were leveled, denoted in the tables as $GMC_S$) increased by 0.62 and 0.78 percent for the fully and partially loaded test, respectively. The conditions for both tests were similar; the only difference was the number of runs. In the Tables 5-1 and 5-2 the differences in error for heavy vehicles can be seen. This error can be caused by the height difference of the truck wheels not compensated for.

**Table 5-1. Summary of the samples' parameters (fully loaded).**

| VEHICLE | GROSS WEIGHT lb[1] | SAMPLE WEIGHT lb[2] | VARIANCE $\sigma^2$ | STANDARD DEVIATION $\sigma$ | COEFFICIENT OF VARIATION | PERCENT ERROR % |
|---|---|---|---|---|---|---|
| Jeep | 5,160 | 5,203 | 737 | 27.2 | 0.52 | 0.83 |
| AT6X6 | 35,060 | 35,308 | 39,871 | 199.7 | 0.57 | 0.71 |
| GMC | 80,890 | 80,267 | 92,096 | 303.5 | 0.39 | 0.77 |
| $GMC_S$ | 80,890 | 79,764 | 10,5383 | 324.6 | 0.41 | 1.39 |
| 3S2 | 69,260 | 69,691 | 12,3026 | 350.7 | 0.50 | 0.62 |

1 Vehicles weighted using the Mississippi scale.
2 Vehicles weighted using the PAT scale.

**Table 5-2. Summary of the samples' parameters (half loaded).**

| VEHICLE | GROSS WEIGHT lb | SAMPLE WEIGHT lb | VARIANCE $\sigma^2$ | STANDARD DEVIATION $\sigma$ | COEFFICIENT OF VARIATION | PERCENT ERROR % |
|---|---|---|---|---|---|---|
| Jeep | 4,170 | 4,172 | 292 | 17.1 | 0.41 | 0.05 |
| AT6X6 | 27,150 | 27,150 | 23,883 | 154.5 | 0.57 | 0.00 |
| GMC | 64,700 | 64,081 | 3,356,302 | 1,832.0 | 2.87 | 0.96 |
| $GMC_S$ | 80,890 | 63,911 | 18164 | 134.8 | 0.21 | 1.22 |
| 3S2 | 52,860 | 53,135 | 53377 | 231.0 | 0.43 | 0.52 |

5.2.2 Normability Test.

Some assumption about the sample distribution must be made in order to perform a statistical analysis. One typical assumption is that the distribution is normal. Figures 5-1 and 5-2 show the frequency histograms for 30 measurements of the weights of the 3S2 vehicle. The frequency histograms indicate a bell-shaped distribution; hence, the assumption of normability seems reasonable. The measured weights are displaced to the right of the true weight. The normal probability plots for the 3S2 truck show the sample values near the diagonal line (see Figures 5-3 and 5-4). This test also supports the normability assumption of the samples.

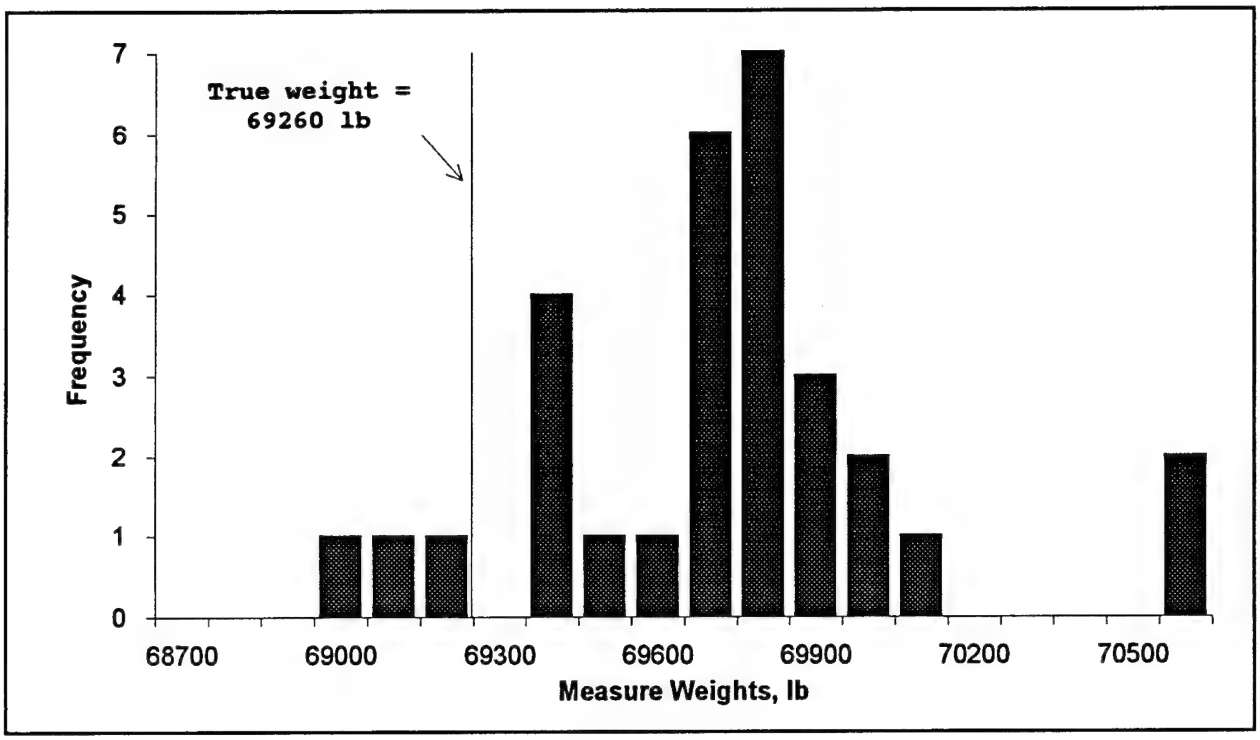


Figure 5-1. Frequency histogram, 3S2 truck (loaded).

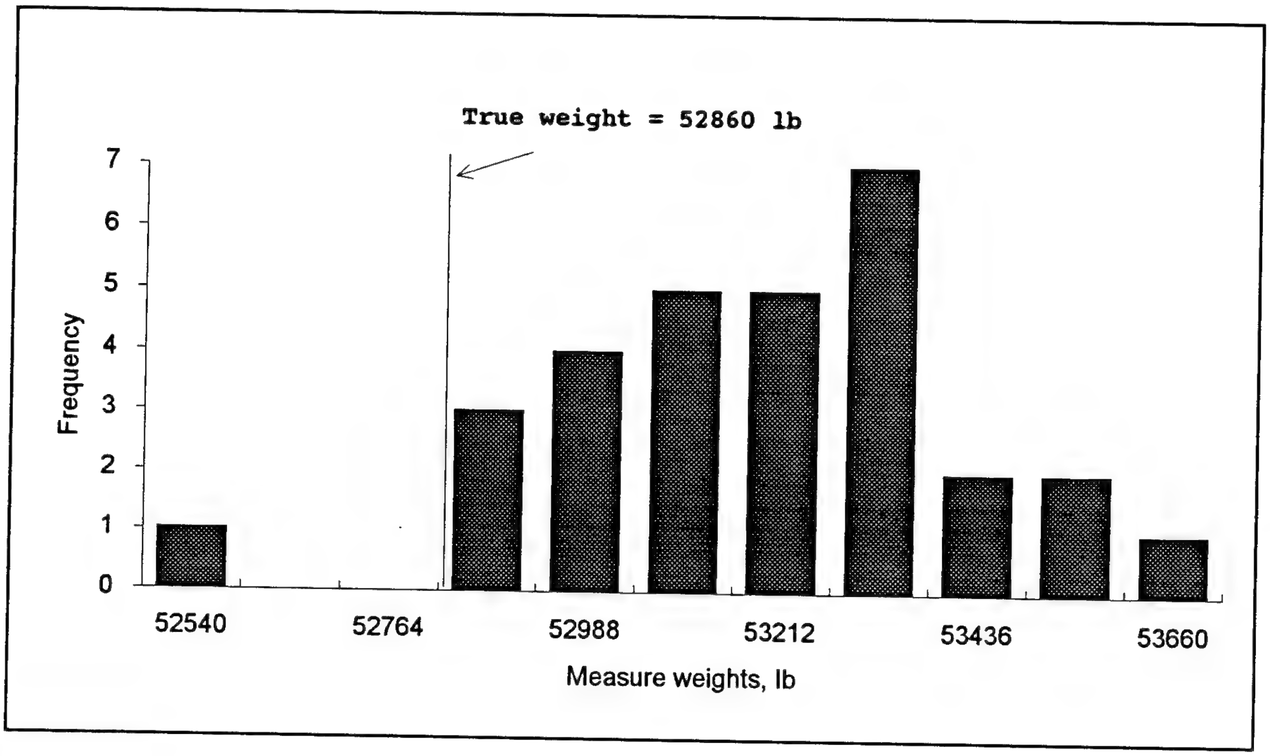


Figure 5-2. Frequency histogram, 3S2 truck (unloaded).

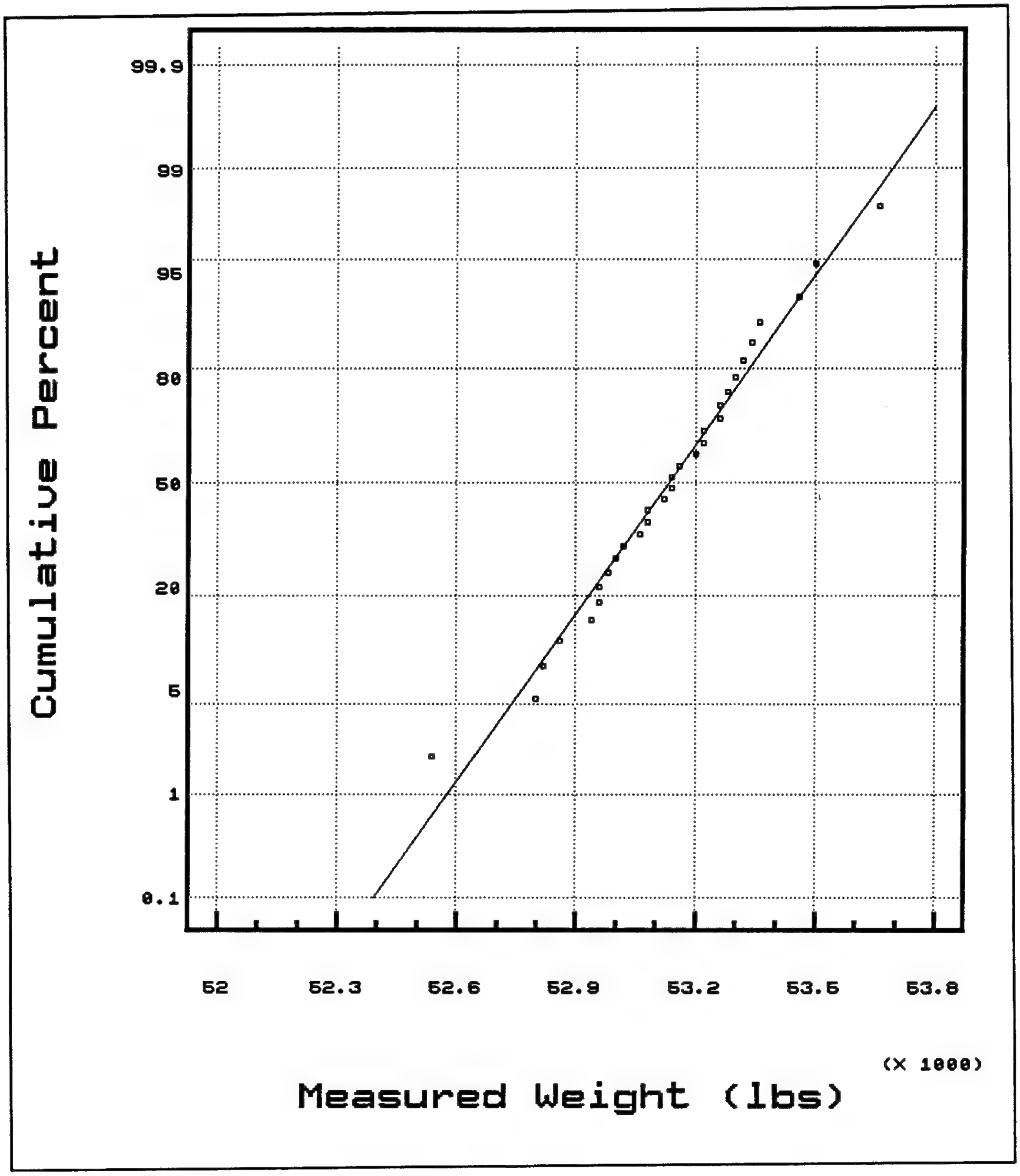


Figure 5-3. Normal probability plot, 3S2 loaded.

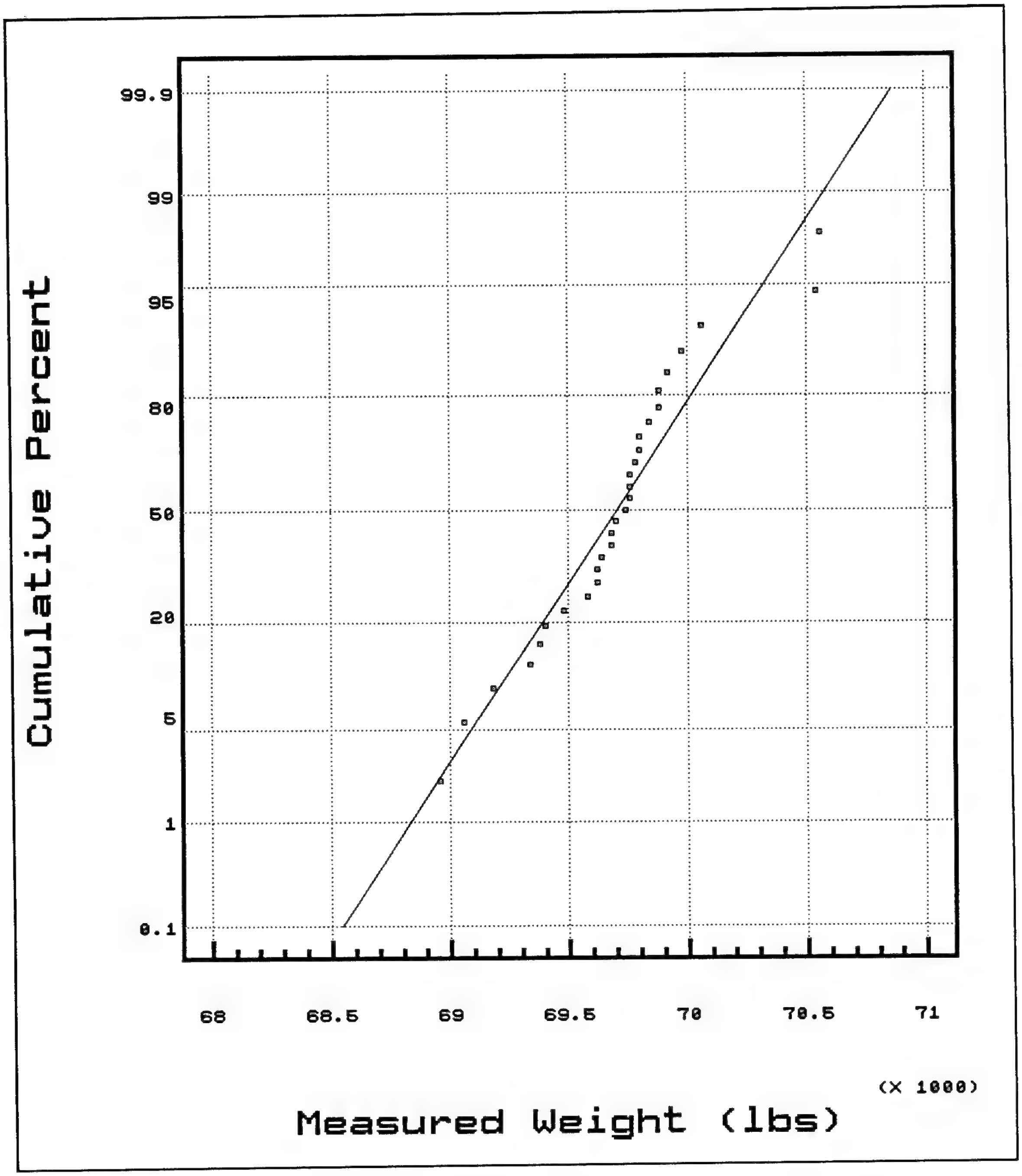


Figure 5-4. Normal probability plot 3S2 unloaded.

### 5.2.3 Detailed Error.

Appendix D shows two tables that show the difference between the true weight and the measured weight of the 3S2 for each of the 30 measurements, in both the loaded and unloaded conditions. These differences indicate the accuracy of the scales because the variation in all cases are less than 1 percent. The difference between the true and measured weight, or error, can be used to evaluate the accuracy of the sample data. The principal objective of this test may be achieved by conducting a statistical analysis on the error. A summary of the results of this analysis appears in Tables 5-3 and 5-4.

**Table 5-3. Statistical parameters for the error (fully loaded).**

| VEHICLE | ERROR | | |
|---|---|---|---|
| | MEAN $\mu$ | STANDARD DEVIATION $\sigma$ | VARIANCE $\sigma^2$ |
| Jeep | 0.008269 | 0.005263 | 0.000028 |
| AT6X6 | 0.007081 | 0.005695 | 0.000032 |
| GMC | -0.007698 | 0.003752 | 0.000014 |
| $GMC_S$ | -0.031920 | 0.004013 | 0.000016 |
| 3S2 | 0.006228 | 0.005064 | 0.000026 |

**Table 5-4. Statistical parameters for the error (half loaded).**

| VEHICLE | ERROR | | |
|---|---|---|---|
| | MEAN $\mu$ | STANDARD DEVIATION $\sigma$ | VARIANCE $\sigma^2$ |
| Jeep | 0.00480 | 0.004104 | 0.000017 |
| AT6X6 | -0.00000 | 0.005692 | 0.000032 |
| GMC | -0.00441 | 0.001752 | 0.000003 |
| $GMC_S$ | -0.01220 | 0.002083 | 0.000004 |
| 3S2 | 0.005196 | 0.004371 | 0.000019 |

### 5.2.4 Population's Mean Versus Sample's Mean.

The test of the hypothesis is another tool to verify if the samples are acceptable. According to Walpole and Myers (1972), the main purpose in selecting samples is to predict information about the unknown population parameters. Statistical inference should then prove if the mean of the sample is equal to the population's mean. Appendix C shows the results of the test of the hypothesis for each sample. For the loaded case, the conclusion was that the sample for each vehicle does not represent the population of interest as shown Table 5-5. For the unloaded case, the conclusion was slip. The samples of the Jeep and AT6X6 vehicles represent the population, but the samples of the GMC and 3S2 vehicles do not represent the population of interest. Using the Analysis of Variance (ANOVA) test, the conclusion for the Jeep, AT6X6, and 3S2 vehicles was that the sample does not represent the population. Therefore, other types of statistical analysis (such as normability test, and histograms) were conducted in order to know more about the characteristics of the population. The results of these tests indicated that the sample represented the characteristics of the population.

**Table 5-5. Test of the hypothesis for the population and sample.**

| VEHICLE | MEAN | | VARIANCE | |
|---|---|---|---|---|
| | LOADED | UNLOADED | LOADED | UNLOADED |
| Jeep | Reject | Accept | Reject | Reject |
| AT6X6 | Reject | Accept | Reject | Accept |
| GMC | Reject | Reject | Reject | Reject |
| $GMC_s$ | Reject | Reject | Accept | Reject |
| 3S2 | Reject | Reject | Reject | Reject |

5.2.5 Number of Runs.

To determine the number of runs necessary to obtain an accuracy of 1 percent, 2 percent, and 3 percent at a confidence level of 95 percent equation 2.1 was used once the statistical hypothesis that was present in the previous paragraph was validated using the normability and histogram plots. Table 5-6 shows the results for each vehicle tested. Only one run is required to obtain 1 percent accuracy for the AT6X6, GMC, and 3S2 trucks. Appendix E shows the variation in the number of runs when the accuracy varies from 1 percent, 2 percent and 3 percent (Mace 1964).

**Table 5-6. Number of runs for 1 percent accuracy at 95 percent confidence level, first approach.**

| VEHICLE | NUMBER OF RUNS 1% accuracy | |
|---|---|---|
| | **Full Load** | **Half Load** |
| Jeep | 2 (1.064) | 1 (0.646) |
| AT6X6 | 1 (0.985) | 1 (0.734) |
| GMC | 1 (0.541) | 1 (0.118) |
| $GMC_S$ | 1 (0.619) | 1 (0.167) |
| 3S2 | 2 (1.246) | 2 (1.245) |

Using the results of the deviation between the true and measured weight, the number of runs can be calculated in a similar way. The error shows the difference of the measured weight with respect to the true weight. This variable can be use to determine the number of runs for a 95 percent confidence level and the accuracy desired (Appendix E). Tables 5-7 and 5-8 show the result for the number of runs. Both approaches do not show significant difference in the results and either approach is acceptable. The Jeep and AT6X6 truck need two runs for 1 percent accuracy but the GMC and 3S2 trucks require one run. Again, only one run is required to obtain 2 and 3 percent accuracy for all the vehicle.

Table 5-7. Number of runs needed to obtain a 95 percent confidence level (loaded), second approach.

| VEHICLE | NUMBER OF RUNS Accuracy | | |
|---|---|---|---|
| | 1 percent | 2 percent | 3 percent |
| Jeep | 2 (1.064) | 1 (0.266) | 1 (0.118) |
| AT6X6 | 2 (1.256) | 1 (0.312) | 1 (0.138) |
| GMC | 1 (0.541) | 1 (0.135) | 1 (0.060) |
| $GMC_S$ | 1 (0.619) | 1 (0.155) | 1 (0.069) |
| 3S2 | 1 (0.985) | 1 (0.246) | 1 (0.109) |

Table 5-8. Number of runs needed to obtain a 95 percent confidence level (unloaded), second approach.

| VEHICLE | NUMBER OF RUNS Accuracy | | |
|---|---|---|---|
| | 1 percent | 2 percent | 3 percent |
| JEEP | 1 (0.650) | 1 (0.160) | 1 (0.070) |
| AT6X6 | 2 (1.240) | 1 (0.310) | 1 (0.140) |
| GMC | 1 (0.120) | 1 (0.030) | 1 (0.010) |
| $GMC_S$ | 1 (0.170) | 1 (0.040) | 1 (0.020) |
| 3S2 | 1 (0.730) | 1 (0.180) | 1 (0.080) |

5.2.6 Confidence Intervals.

The confidence intervals' length indicates the precision or accuracy of an estimate (average of sample's mean). Also, it is better to have a short interval with a high degree of confidence. Equation 5.1 shows the expression used to calculate the intervals. Appendix F shows the 95 percent confidence level for all the samples. The range of confidence intervals for the mean are shorter than those for the variance.

$$\mu_{sample} - Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}} < \mu < \mu_{sample} + Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}} \qquad (5.1)$$

where

$\mu_{sample}$ = mean of a sample

$Z_{\frac{\alpha}{2}}$ = value of the standard normal distribution (critical value)

$\sigma$ = standard deviation of the sample

n = sample size

Table 5-9 shows the mean and standard deviation confidence interval for each vehicle. The confidence intervals range for the PAT scales weighing measurements are short indicating that the scales have high degree of confidence or accuracy in the prediction of vehicle weight. When the scale is not available, the vehicle weight can be estimated using the intervals values. The intervals values can be used only if the conditions of the test are similar.

**Table 5-9. Confidence intervals.**

| VEHICLE | CONFIDENCE INTERVALS RANGE[1] | |
|---|---|---|
| | MEAN $\mu$ | STANDARD DEVIATION $\sigma^2$ |
| Jeep | 19.4 | 6,796.5 |
| AT6X6 | 251.0 | 1,133,839.0 |
| GMC | 217.2 | 848,782.6 |
| $GMC_S$ | 232.3 | 971,237.1 |
| 3S2 | 142.9 | 367,460.3 |

[1] $Range = 2 Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}}$

### 5.2.7 Analysis for the Loaded and Unloaded Cases.

The loaded and unloaded samples for each vehicle were compared. Statistical inferences about the mean and the variance for both samples were analyzed to see if any significant differences exist between the samples (see Appendix C). Tests of the hypothesis of equality of the means and variance of the loaded and unloaded cases show that both samples are different. The ANOVA was used to compare the equality of the samples' mean, while Cochran's test was used for the variance.

# SECTION 6

# RESULTS

## 6.1 CHECK OF DATA.

The continuous check of data gathered avoided an increase in the deviation between the runs. The results of that action can be observed in the percent error. The error for each sample was less than 2 percent which indicates that the samples are reliable. For the set of partially-loaded tests, the percent error was less than those for the fully loaded case. The heavy vehicles present an increase in error as seen in Tables 5-1 and 5-2. The error fluctuates from 0.77 to 1.39 for the fully loaded case, and from 0 to 1.22 for the unloaded case.

All the samples gathered demonstrated adequate populations. Once this affirmation was verified, the number of runs needed for most cases was 1. A wide range for the confidence interval of the variance was obtained, but for the mean the interval is narrow (see Table 5-9).

## 6.2 DIFFERENCES.

Significant differences existed between the unloaded and loaded samples. For most cases the hypothesis that tests the mean between both conditions was rejected. It is evident that the difference in weight implies that the populations are not similar. For the AT6X6 truck the results in variance for both samples are equal. In the special test for the GMC, the ANOVA analysis shows that the sample means are equal. This result can be caused by two main factors. First, the sample size for this test was 15 observations for unloaded and loaded conditions. Second, the vehicle differs in height with respect to the scales. Only the adjacent axles to the scale had the same height as the scales.

The difference between the true and measured weights give a better estimate of the number of runs. The number of runs calculated in the two case (error and the sample) are similar. In both analyses the results are consistent for the loaded and unloaded test.

## SECTION 7

## CONCLUSIONS AND RECOMMENDATIONS

### 7.1 CONCLUSIONS.

a. PAT scales accuracy - The PAT SAW 10c portable static scales were capable of weighing multiaxle vehicle, over a wide range of loads (Table 3-1), to an accuracy of ±1 percent of the gross vehicle weight. The percent of error between the gross weight and the sample weight fluctuated from 0.83 for the Jeep to 0.62 for the 3S2 truck, showing error less than 1 percent. The number of runs was less or equal to 2 runs. The scales precision can be showed by the consistent weighing measures (Figure 5-1 and 5-2). Also, the confidence intervals range for the PAT scales weighing measurements indicate that the scales have high degree of confidence in the prediction of vehicle weight.

b. Portable static scale data acquisition - The research proposes guidelines for data acquisition using the portable static scales. The guidelines were used in the field test showing a reduction of time and effort needed to weigh vehicles. The number of observations needed for the 1 percent accuracy sample was determined prior to the field test. Once the scales and the boards were installed the data acquisition was a repetitive activity. For this particular test, an accuracy of 1 percent at a 95 percent confidence level can be obtained with the four test vehicles if care is taken with respect to blocking, position of the axles on the PAT scale, and alignment of the vehicle.

c. Loaded versus unloaded - There does not appear a significant difference between the loaded and unloaded conditions when determining the number of runs with an accuracy of 1 percent at 95 percent confidence level. The percent of errors for the PAT data are greater for loaded vehicles than for the unloaded vehicles. The PAT scales sensitivity due to the load conditions could be attributed to the vehicle dynamic mechanism (spring, shock absorbers, etc.).

d. Number of test - Small samples can represent the population if the data are gathered with special care. The sample size needed to obtain the desired precision does not need to be large. Better results can be obtained by studying typical behavior of a particular vehicle using old data and information. The sample size (number of tests) varied between 1 to 2 tests. This conclusion supported that the portable static scales were capable of weighing multiaxle vehicles to an accuracy of ±1 percent of the gross vehicle weight. In addition, this implies less time and less vehicle operating cost on the field with the desired accuracy in the results.

e. Axles height difference - The special test for the GMC truck ($GMC_s$) shows the results when the vehicle is not level or the axles are not in line with the axle over the PAT scales. The results indicate that the vehicle axles need to be at the same height as the axle over the scales using dummy boards. This compensation can reduce the error in the measurement because the magnitude of dynamic and diagonal forces will be less.

## 7.2 RECOMMENDATIONS AND COMMENTS.

a. This PAT SAW 10c scales can be used for measurements of wheel load weights up to 20,000 lb or single axle weights up to 40,000 lb. It is recommended to evaluate the accuracy of the scales with other type of vehicles. For example, the scales can be used to weight aircraft that do not exceed the previous scale limits.

b. Additional investigation needs to be conducted on the scales when the testing site geometry, environmental, and surface conditions are different from the manufacturer recommendations. For example, the surface can be unpaved or paved with a 2 percent slope. On the other hand, extreme temperatures may affect the scale accuracy. An experiment could be designed to evaluate how the environmental conditions can affect the number of test and the scale accuracy.

c. The leveling boards had a tendency to slip in most cases. Drivers should avoid abrupt stops and starts which cause slippage of the leveling boards. A literature review could be useful to provide information about the leveling board for future studies. The adequate leveling board can avoid inaccuracy in the process.

d. The next observations explain few situations which prolonged the field test and affected the number of test that were required to determine if the scales were capable of weighing multiaxle vehicles to a desire accuracy. First, the drivers need more time to center wheels over the dummy boards because they are narrow. Using wider boards made of some other material can help to reduce time in data collection and error in the data. Second, marks were put on the scale in order to center the tires when testing the vehicles, this helped obtain more accuracy in the data. Third, vehicles with automatic transmissions are easier to control. Finally, a review of the statistical concepts may help in the field; for example, by having some idea what the approximate deviation between the sample observations that can be tolerated will help to identify outlier values in the data that would lead to errors in the sample predictions.

## SECTION 8

## REFERENCES


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## APPENDIX A

## PREVIOUS PAT DATA ANALYSIS

### A.1 INTRODUCTION.

As mention previously, the test objectives were to familiarize with the PAT scale use and setup, and to evaluate if the PAT scale replicability can changed with the weighing direction (north or south). Only ten runs were collected for each vehicle in that test. The test results were used to design the test conducted in July 23-25, 1992 which evaluated the scales accuracy. The statistical analysis of the data shows that there is no significant difference between the data collected from the two directions (north and south). Assuming a level straight approach, the vehicles need only be weighed in one direction to save time in obtaining the data that represent the whole population. On other hand, the sample for each of the vehicles does not represent the entire population. This problem implies that the conclusions and recommendations that can be made using these samples were not reliable. The samples reliability were needed to estimate the number of tests that were required to determine if the portable static scales were capable of weighing multiaxle vehicles to an accuracy of ±1 percent of the gross vehicle weight.

Some decisions need to be made using samples of a particular population. The results of the sampling experiment are used to predict the consequences of making specific engineering decisions for the total population. It is important that the sample be random and be the correct size because it will be used as a representation of the entire population.

When the collection of data is needed for the study or to analyze the characteristics of a group of objects, people, etc., it is sometime impossible or impractical to observe the entire group, specifically if this group is large. Instead of gathering all the group (population), some samples that describe the entire population can be obtained. Important conclusions about the population can often be inferred from analyzing the sample, if the sample is representative of a population. Samples that can be gathered in the field are of two sizes: small ($n < 30$) and large ($n \geq 30$). It important to know that with large samples a greater precision in the results can be gathered, but it implies a lot of investment in time and money. A good balance between the confidence level and the investment needs to be found. The purpose of this appendix is to discuss the importance of sample size and how to secure it in the field according to the purpose of the research.

### A.2 SMALL SAMPLES.

The collection of small samples is more economical because the time and the human and non-human resources that were used to gather it is less than the time needed to gather a large sample. The statistic used for small samples are based on two distributions, the t and the chi-square and the results that it provides are more accurate. The *t*

distribution's curve is symmetrical or bell-shaped and very similar to the normal curve. Also, the statistics inference that we can make about it are very similar to the normal distribution inference. With these distributions we can define 95 percent, 99 percent or other confidence limits and intervals using the table distribution that appears in some statistics books (Walpole 1972 and Montgomery 1980). These tables are defined for $n \le 30$, in other cases, use the normal tables. The first equation is for the confidence limits for population means using the t distribution. Using this equation, the specific confidence level and the accuracy that is desired in the results can be obtained.

$$\bar{X} \pm t_c \frac{s}{\sqrt{(N-1)}} \qquad \textbf{(A.1)}$$

where

X = means
$t_c$ = critical value or confidence coefficient
s = standard deviation
N = sample size

The critical value ($t_c$) depends on the level of confidence desired and the sample size it can be obtained from tables.

Another distribution used for the analysis of the small samples is the chi-square distribution. The curve for this distribution is skewed to the right or has a positive skew, but when the sample size increases the shape of the curve become more symmetrical. As with the t distribution, we can define 95 percent, 99 percent or other confidence limits and intervals for chi-square by the use of the chi-square distribution tables. With this method, the population standard deviation ($\sigma$) in terms of a sample standard deviation (s) can be estimated. Equation A-2 shows the confidence interval for the confidence level and accuracy desired in the standard deviation.

$$\frac{s\sqrt{N}}{X_{1-\alpha}} < \sigma < \frac{s\sqrt{N}}{X_{\alpha}} \qquad \textbf{(A.2)}$$

where

$\sigma$ = standard deviation of the population
s = standard deviation of the sample
N = sample size
X = critical value for chi-square distribution
$\alpha$ = error type 1

A.3 LARGE SAMPLES.

Large samples use normal distribution for statistic inference. The size of the sample needs to be known to ensure that the error in estimating $\mu$ will be less than the specified amount of an error (e). See the next illustration.

$$\overset{\text{Error (e)}}{\longleftrightarrow}$$

$$\overline{X} - Z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}} \qquad\qquad \overline{X} + Z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}}$$

Two theorems exist to solve this problem which includes the confidence level and the accuracy wanted in the results. The theorems were obtained from probability and statistic books (Walpole 1972 and Montgomery 1980).

Theorem 1. If x is used as an estimate of $\mu$, we can be $(1-\alpha)100$ percent confident that the error will be less than $Z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}}$.

Theorem 2. If x is used as an estimate of $\mu$, we can be $(1-\alpha)100$ percent confident that the error will be less than a specified amount e when the sample size is,

$$n = \left[\frac{Z_{\frac{\alpha}{2}}\,\sigma}{e}\right]^2 \tag{A.3}$$

The formula in the second theorem is only applicable if the variance of the population from the sample is known. The preliminary sample size of $n \geq 30$ could be used to provide an estimate of $\sigma$ and then can use the previous equation to find the number of observations that are needed to provide the desired degree of accuracy and confidence level.

## A.4 PROBLEM TO SOLVE.

The correct amount of running with and without leveling boards that can be collected in the field to get a 95 percent confidence level and 3 percent, 2 percent and 1 percent accuracy in our results need to be estimated. The literature review shows the need to obtain a preliminary sample ($n \geq 30$) to get the variance and then calculate the number of running. In addition, if the direction (north and south) in the data collection has an important implication.

## A.5 PRELIMINARY CONCLUSION.

The sample size that can be calculated using a 95 percent of accuracy, $\alpha = 0.05$ and the estimated variance. The assumption that the mean of the sample is equal to the mean of the population is not true. The use of the analysis of variance can help us to determine if the direction in which the data were gathered has a significant difference. We use the statistical inference to prove if the means and variance between the south and north direction were different. In conclusion, we obtain that the means between the south sample and the north sample are equal. Also, the statistical inference proves the variance between the direction are equal. The results were obtained for a 95 percent of confidence level and $\alpha = 0.05$.

TESTING IF THE MEANS OF NORTH AND SOUTH DIRECTION ARE SIGNIFICANTLY DIFFERENT

| DATE | VEH | DIR | BOARDS | SCALE | WEIGHT | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05/21/92 | GMC | S | | SAS | 48320 | 49520 | 49480 | 49240 | 49540 | 49440 | 50368 | 49320 | 49220 |
| 05/21/92 | GMC | N | | SAS | 48320 | 49140 | 49040 | 48980 | 49020 | 48940 | 49500 | 47240 | 49260 |
| 05/22/92 | GMC | S | | PAT | 48320 | 55440 | 55440 | 54980 | 55440 | 55680 | | | |
| 05/22/92 | GMC | N | | PAT | 48320 | 54880 | 55360 | 55500 | 54380 | 54820 | | | |
| 05/22/92 | GMC | S | WB | PAT | 80700 | 82220 | 81940 | 81960 | 81960 | 80520 | 88860 | 89100 | 88260 |
| 05/22/92 | GMC | N | WB | PAT | 80700 | 81280 | 81540 | 80820 | 81260 | 81540 | 87520 | 83400 | 88580 |
| 05/22/92 | BLUE T | S | WB | PAT | 69070 | 70240 | 69420 | 69880 | 69320 | 69540 | 71800 | 71740 | 70820 |
| 05/22/92 | BLUE T | N | WB | PAT | 69070 | 69320 | 68960 | 69620 | 69680 | 70200 | 70080 | 71340 | 70580 |
| 05/21/92 | TRACT | S | WB | PAT | 36630 | 37200 | 37140 | 37120 | 37460 | 37600 | 37660 | 36980 | 36860 |
| 05/21/92 | TRACT | N | WB | PAT | 36630 | 36740 | 37300 | 37300 | 37020 | 36720 | 37320 | 38540 | 37640 |

| DATE | VEH | DIR | BOARDS | SCALE | WEIGHT | R9 | R10 | R11 | R12 | R13 | R14 | R15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05/21/92 | GMC | S | | SAS | 48320 | 49620 | 48560 | | | | | |
| 05/21/92 | GMC | N | | SAS | 48320 | 49500 | 49860 | | | | | |
| 05/22/92 | GMC | S | | PAT | 48320 | | | | | | | |
| 05/22/92 | GMC | N | | PAT | 48320 | | | | | | | |
| 05/22/92 | GMC | S | WB | PAT | 80700 | 87160 | 86040 | | | | | |
| 05/22/92 | GMC | N | WB | PAT | 80700 | 88820 | 88340 | | | | | |
| 05/22/92 | BLUE T | S | WB | PAT | 69070 | 71100 | 71240 | | | | | |
| 05/22/92 | BLUE T | N | WB | PAT | 69070 | 71980 | 71700 | | | | | |
| 05/21/92 | TRACT | S | WB | PAT | 36630 | 37360 | 38080 | 38480 | 38640 | 39080 | 37920 | 38560 |
| 05/21/92 | TRACT | N | WB | PAT | 36630 | 36860 | 36540 | 38140 | 39200 | 39140 | 38180 | 38240 |

Ho: The mean of the south and north direction are equal
Ho: The mean of the south and north direction are not equal

| | |
|---|---|
| alpha= | 0.05 |
| C. I.= | 0.95 |

DIFFERENCE BETWEEN SOUTH AND NORTH

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| di | 380 | 440 | 260 | 520 | 500 | 868 | 2080 | -40 | 120 | -1300 | | | |
| | 560 | 80 | -520 | 1060 | 860 | | | | | | | | |
| | 940 | 400 | 1140 | 700 | -1020 | 1340 | 5700 | -320 | -1660 | -2300 | | | |
| | 920 | 460 | 260 | -360 | -660 | 1720 | 400 | 240 | -880 | -460 | | | |
| | 460 | -160 | -180 | 440 | 880 | 340 | -1560 | -780 | 500 | 1540 | 340 | -560 | -60 |
| | | | | | | | | | | | | -260 | 320 |

| di(mean) | di(std | n | DF | t | Tcrit1 | Tcrit2 | Conclusion |
|---|---|---|---|---|---|---|---|
| 382.8 | 833.1 | 10 | 9 | 1.453 | -2.262 | 2.262 | The two directions are not significatly different |
| 408 | 636.6 | 5 | 4 | 1.433 | -2.776 | 2.776 | The two directions are not significatly different |
| 492 | 2208 | 10 | 9 | 0.705 | -2.262 | 2.262 | The two directions are not significatly different |
| 164 | 787.7 | 10 | 9 | 0.658 | -2.262 | 2.262 | The two directions are not significatly different |
| 92.30769 | 782 | 15 | 14 | 0.457 | -2.145 | 2.145 | The two directions are not significatly different |

Scale:Single axle
date: 5-21-92
Vehicle: 4 axles-GMC
Total Weight West 48300 Total Weight East: 48340 Average 48320

Direction: south

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 16140 | 16160 | 16100 | 16180 | 16140 | 16144 | 29.665 | 880 | 0.184 |
| 2 | 13760 | 13700 | 13640 | 13720 | 13660 | 13696 | 47.749 | 2280 | 0.349 |
| 3 | 11840 | 11840 | 11720 | 11780 | 11760 | 11788 | 52.154 | 2720 | 0.442 |
| 4 | 7780 | 7780 | 7780 | 7860 | 7880 | 7816 | 49.800 | 2480 | 0.637 |
| Total | 49520 | 49480 | 49240 | 49540 | 49440 | 49444 | 120.333 | 14480 | 0.243 |
| Error | 2.4233 | 2.3444 | 1.8684 | 2.4627 | 2.2654 | 2.2733 | | | |

Direction: north

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15540 | 15460 | 15500 | 15480 | 15500 | 15496 | 29.665 | 880 | 0.191 |
| 2 | 14060 | 14060 | 14020 | 14080 | 14020 | 14048 | 26.833 | 720 | 0.191 |
| 3 | 10960 | 10980 | 10920 | 10920 | 10900 | 10936 | 32.863 | 1080 | 0.301 |
| 4 | 8580 | 8540 | 8540 | 8540 | 8520 | 8544 | 21.909 | 480 | 0.256 |
| Total | 49140 | 49040 | 48980 | 49020 | 48940 | 49024 | 75.366 | 5680 | 0.154 |
| Error | 1.6687 | 1.4682 | 1.3475 | 1.428 | 1.2669 | 1.436 | | | |
| Dif. between North and South | 0.7546 | 0.8153 | 0.7177 | 0.797 | 0.8372 | | | | |

Scale:PAT
date: 5-22-92
Vehicle: 4 axles-GMC
Total Weight West 48300 Total Weight East: 48340 Average 48320

Direction: south

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 17120 | 17040 | 17160 | 17320 | 17220 | 17172 | 105.451 | 11120 | 0.614 |
| 2 | 14940 | 15060 | 15080 | 14940 | 15100 | 15024 | 77.974 | 6080 | 0.519 |
| 3 | 13720 | 13640 | 13540 | 13540 | 13640 | 13616 | 76.681 | 5880 | 0.563 |
| 4 | 9660 | 9700 | 9200 | 9640 | 9720 | 9584 | 216.979 | 47080 | 2.264 |
| Total | 55440 | 55440 | 54980 | 55440 | 55680 | 55396 | 254.716 | 64880 | 0.46 |
| Error | 12.843 | 12.843 | 12.113 | 12.843 | 13.218 | 12.773 | | | |

Direction: north

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 16620 | 16560 | 16640 | 16280 | 16380 | 16496 | 158.367 | 25080 | 0.96 |
| 2 | 14860 | 15260 | 15160 | 14740 | 15100 | 15024 | 216.518 | 46880 | 1.441 |
| 3 | 12940 | 13020 | 13060 | 12940 | 12920 | 12976 | 60.663 | 3680 | 0.468 |
| 4 | 10460 | 10520 | 10640 | 10420 | 10420 | 10492 | 92.304 | 8520 | 0.88 |
| Total | 54880 | 55360 | 55500 | 54380 | 54820 | 54988 | 450.022 | 202520 | 0.818 |
| Error | 11.953 | 12.717 | 12.937 | 11.144 | 11.857 | 12.126 | | | |
| Dif. between North and South | 0.889 | 0.126 | 0.823 | 1.699 | 1.361 | | | | |

Scale:PAT without boards
date: 5-22-92
Vehicle: 4 axles-GMC
Total Weight West 80680    Total Weight East: 80720    Average 80700

Direction: south

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20000 | 19980 | 20080 | 20000 | 19980 | 20008 | 41.473 | 1720 | 0.207 |
| 2 | 19380 | 19320 | 19420 | 19240 | 19360 | 19344 | 68.411 | 4680 | 0.354 |
| 3 | 22860 | 22960 | 23080 | 22780 | 21240 | 22584 | 759.658 | 577080 | 3.364 |
| 4 | 19980 | 19680 | 19380 | 19940 | 19940 | 19784 | 255.500 | 65280 | 1.291 |
| Total | 82220 | 81940 | 81960 | 81960 | 80520 | 81720 | 680.735 | 463400 | 0.833 |
| Error | 1.8487 | 1.5133 | 1.5373 | 1.5373 | 0.2235 | 1.2482 | | | |

Direction: north

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 18620 | 19060 | 19180 | 19060 | 19060 | 18996 | 216.518 | 46880 | 1.14 |
| 2 | 19620 | 19460 | 19160 | 19680 | 19520 | 19488 | 202.287 | 40920 | 1.038 |
| 3 | 22040 | 22020 | 21740 | 21780 | 22020 | 21920 | 146.969 | 21600 | 0.67 |
| 4 | 21000 | 21000 | 20740 | 20740 | 20940 | 20884 | 133.716 | 17880 | 0.64 |
| Total | 81280 | 81540 | 80820 | 81260 | 81540 | 81288 | 294.483 | 86720 | 0.362 |
| Error | 0.0071 | 0.0103 | 0.0015 | 0.0069 | 0.0103 | 0.0072 | | | |

Dif. between North and South

| | | | | |
|---|---|---|---|---|
| 1.8416 | 1.6726 | 1.627 | 1.6029 | 1.2409 |

Scale:PAT without boards
date: 5-22-92
Vehicle: 4 axles-GMC
Total Weight West 80680    Total Weight East: 80720    Average 80700

Direction: south

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20500 | 20500 | 20380 | 20200 | 20300 | 20376 | 129.923 | 16880 | 0.638 |
| 2 | 21220 | 21220 | 21120 | 20800 | 21020 | 21076 | 175.157 | 30680 | 0.831 |
| 3 | 23860 | 24220 | 23740 | 23800 | 23120 | 23748 | 397.643 | 158120 | 1.674 |
| 4 | 23280 | 23160 | 23020 | 22360 | 21600 | 22684 | 702.624 | 493680 | 3.097 |
| Total | 88860 | 89100 | 88260 | 87160 | 86040 | 87884 | 1274.472 | 1.6E+06 | 1.45 |
| Error | 9.183 | 9.4276 | 8.5656 | 7.4117 | 6.2064 | 8.1744 | | | |

Direction: north

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20780 | 21060 | 21240 | 21320 | 21240 | 21128 | 216.610 | 46920 | 1.025 |
| 2 | 20780 | 20060 | 20740 | 20680 | 20620 | 20576 | 294.754 | 86880 | 1.433 |
| 3 | 20340 | 22060 | 25060 | 25040 | 24520 | 24204 | 1239.63 | 2E+06 | 5.122 |
| 4 | 21620 | 20220 | 21540 | 21780 | 21960 | 21424 | 692.01 | 478880 | 3.230 |
| Total | 87520 | 83400 | 88580 | 88820 | 88340 | 87332 | 2251.87 | 5E+06 | 2.579 |
| Error | 7.793 | 3.237 | 8.896 | 9.142 | 8.648 | 7.594 | | | |

Dif. between North and South

| | | | | |
|---|---|---|---|---|
| 1.39 | 6.19 | 0.33 | 1.73 | 2.44 |

Scale:PAT without boards
date: 5-21-92
Vehicle: Blue Trucks
Total Weight West 69020 Total Weight East: 69120 Average 69070

Direction: south

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9640 | 9440 | 9500 | 9360 | 9400 | 9468 | 109.179 | 11920 | 1.153 |
| 2 | 14380 | 13800 | 14060 | 13920 | 14120 | 14056 | 219.727 | 48280 | 1.563 |
| 3 | 13800 | 13820 | 13780 | 13780 | 13640 | 13764 | 71.274 | 5080 | 0.518 |
| 4 | 16460 | 16200 | 16400 | 16280 | 16320 | 16332 | 101.587 | 10320 | 0.622 |
| 5 | 15960 | 16160 | 16140 | 15980 | 16060 | 16060 | 90.554 | 8200 | 0.564 |
| Total | 70240 | 69420 | 69880 | 69320 | 69540 | 69680 | 377.624 | 142600 | 0.542 |
| Error | 1.6657 | 0.5042 | 1.1591 | 0.3606 | 0.6759 | 0.8754 | | | |

Direction: north

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9220 | 9600 | 9160 | 9260 | 9160 | 9280 | 183.848 | 33800 | 1.981 |
| 2 | 14060 | 13420 | 14280 | 13900 | 14420 | 14016 | 388.433 | 150880 | 2.771 |
| 3 | 13800 | 13980 | 14020 | 14180 | 14120 | 14020 | 146.287 | 21400 | 1.043 |
| 4 | 16280 | 16340 | 16340 | 16300 | 16300 | 16312 | 26.833 | 720 | 0.164 |
| 5 | 15960 | 15620 | 15820 | 16040 | 16200 | 15928 | 220.273 | 48520 | 1.383 |
| Total | 69320 | 68960 | 69620 | 69680 | 70200 | 69556 | 459.652 | 211280 | 0.661 |
| Error | 0.3606 | 0.1595 | 0.79 | 0.8754 | 1.6097 | 0.6987 | | | |

Dif. between North and South
1.3051 0.9871 0.7801 0.4569 0.1767

Scale:PAT without boards
date: 5-22-92
Vehicle: Blue Trucks
Total Weight West 69020 Total Weight East: 69120 Average 69070

Direction: south

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9560 | 9380 | 9340 | 9520 | 9660 | 9492 | 131.605 | 17320 | 1.386 |
| 2 | 14540 | 14540 | 14120 | 13940 | 14080 | 14244 | 278.352 | 77480 | 1.954 |
| 3 | 14240 | 14260 | 14160 | 14280 | 14400 | 14268 | 86.718 | 7520 | 0.608 |
| 4 | 16740 | 16780 | 16780 | 16640 | 16640 | 16716 | 71.274 | 5080 | 0.426 |
| 5 | 16720 | 16780 | 16420 | 16720 | 16460 | 16620 | 166.733 | 27800 | 1.003 |
| Total | 71800 | 71740 | 70820 | 71100 | 71240 | 71340 | 421.189 | 177400 | 0.59 |
| Error | 3.8022 | 3.7218 | 2.4711 | 2.8551 | 3.046 | 3.1819 | | | |

Direction: north

| Axles | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 8820 | 9780 | 8940 | 9420 | 9740 | 9340 | 444.522 | 197600 | 4.759 |
| 2 | 14340 | 14540 | 14680 | 15000 | 14060 | 14524 | 353.667 | 125080 | 2.435 |
| 3 | 13860 | 13740 | 13920 | 14560 | 14500 | 14116 | 384.031 | 147480 | 2.721 |
| 4 | 16440 | 16460 | 16520 | 16460 | 16520 | 16480 | 37.417 | 1400 | 0.227 |
| 5 | 16620 | 16820 | 16520 | 16540 | 16880 | 16676 | 164.560 | 27080 | 0.987 |
| Total | 70080 | 71340 | 70580 | 71980 | 71700 | 71136 | 789.987 | 624080 | 1.111 |
| Error | 1.4412 | 3.1819 | 2.1394 | 4.0428 | 3.6681 | 2.9043 | | | |

Dif. between North and South
2.361 0.540 0.332 1.188 0.622

Scale:PAT without boards
date: 5-21-92
Vehicle: Blue Tractor lowboy
Total Weight West 36600 Total Weight East: 36660 Average 36630

Direction: south Run

| | Axles | 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 9860 | 9720 | 9740 | 9700 | 9720 | 9748 | 64.187 | 4120 | 0.658 |
| | 2 | 7740 | 7820 | 7940 | 7860 | 8140 | 7900 | 152.315 | 23200 | 1.928 |
| | 3 | 7180 | 7140 | 7320 | 7400 | 7260 | 7260 | 104.881 | 11000 | 1.445 |
| | 4 | 6260 | 6280 | 6120 | 6260 | 6280 | 6240 | 67.823 | 4600 | 1.087 |
| | 5 | 6160 | 6180 | 6000 | 6240 | 6200 | 6156 | 92.087 | 8480 | 1.496 |
| Total | | 37200 | 37140 | 37120 | 37460 | 37600 | 37304 | 214.196 | 45880 | 0.574 |
| Error | | 0.0153 | 0.0137 | 0.0132 | 0.0222 | 0.0258 | 0.0181 | | | |

Direction: north Run

| | Axles | 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 9640 | 9720 | 9640 | 9560 | 9620 | 9636 | 57.271 | 3280 | 0.594 |
| | 2 | 7320 | 7860 | 7740 | 7540 | 7280 | 7548 | 254.008 | 64520 | 3.365 |
| | 3 | 7360 | 7300 | 7300 | 7400 | 7200 | 7312 | 75.631 | 5720 | 1.034 |
| | 4 | 6160 | 6100 | 6280 | 6200 | 6280 | 6204 | 77.974 | 6080 | 1.257 |
| | 5 | 6260 | 6320 | 6340 | 6320 | 6340 | 6316 | 32.863 | 1080 | 0.52 |
| Total | | 36740 | 37300 | 37300 | 37020 | 36720 | 37016 | 285.096 | 81280 | 0.77 |
| Error | | 0.2994 | 1.7962 | 1.7962 | 1.0535 | 0.2451 | 1.0428 | | | |

Dif. between North and South
1.2329 0.3993 0.1063 0.3714 0.764

Scale:PAT without boards
date: 5-22-92
Vehicle: Blue Tractor lowboy
Total Weight West 36600 Total Weight East: 36660 Average 36630

Direction: south
Right: Front Run

| | Wheel | 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 4920 | 4660 | 4940 | 5000 | 5120 | 4928 | 168.879 | 28520 | 3.427 |
| | 2 | 3800 | 4260 | 3720 | 3680 | 3900 | 3872 | 232.637 | 54120 | 6.008 |
| | 3 | 3640 | 3420 | 3460 | 3580 | 3700 | 3560 | 118.322 | 14000 | 3.324 |
| | 4 | 3100 | 2900 | 2980 | 2860 | 2860 | 2940 | 101.980 | 10400 | 3.469 |
| | 5 | 3440 | 3280 | 3260 | 3260 | 3200 | 3288 | 90.111 | 8120 | 2.741 |
| Total | | 18900 | 18520 | 18360 | 18380 | 18780 | 18588 | 241.909 | 58520 | 1.301 |

Left: Front Run

| | Wheel | 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 5100 | 4960 | 5000 | 5200 | 5180 | 5088 | 106.395 | 11320 | 2.091 |
| | 2 | 3960 | 3620 | 3560 | 3800 | 3980 | 3784 | 191.520 | 36680 | 5.061 |
| | 3 | 3500 | 3680 | 3560 | 3780 | 3680 | 3640 | 110.454 | 12200 | 3.034 |
| | 4 | 3220 | 3260 | 3440 | 3220 | 3420 | 3312 | 109.179 | 11920 | 3.296 |
| | 5 | 2980 | 2940 | 2940 | 2980 | 3040 | 2976 | 40.988 | 1680 | 1.377 |
| Total | | 18760 | 18460 | 18500 | 18980 | 19300 | 18800 | 349.857 | 122400 | 1.861 |
| Total weight | | 37660 | 36980 | 36860 | 37360 | 38080 | 37388 | | | |
| Error | | 2.735 | 0.9465 | 0.624 | 1.954 | 3.8078 | 2.0274 | | | |

Direction: north

Left: Front

| Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5060 | 4860 | 4960 | 4860 | 4860 | 4920 | 89.443 | 8000 | 1.818 |
| 2 | 3840 | 3800 | 3560 | 3980 | 3640 | 3764 | 166.373 | 27680 | 4.42 |
| 3 | 4040 | 3840 | 3640 | 3820 | 3780 | 3824 | 143.805 | 20680 | 3.761 |
| 4 | 3180 | 3160 | 3000 | 2880 | 2920 | 3028 | 136.821 | 18720 | 4.519 |
| 5 | 2920 | 4140 | 3020 | 2960 | 2980 | 3204 | 524.481 | 275080 | 16.37 |
| Total | 19040 | 19800 | 18180 | 18500 | 18180 | 18740 | 688.912 | 474600 | 3.676 |

Right: Front

| Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4980 | 4840 | 4980 | 4860 | 4860 | 4904 | 69.857 | 4880 | 1.424 |
| 2 | 3300 | 3580 | 3660 | 3520 | 3520 | 3516 | 133.716 | 17880 | 3.803 |
| 3 | 3540 | 3700 | 3700 | 3440 | 3440 | 3564 | 130.690 | 17080 | 3.667 |
| 4 | 3160 | 3100 | 3600 | 3020 | 3020 | 3180 | 242.074 | 58600 | 7.612 |
| 5 | 3300 | 3520 | 3520 | 3520 | 3520 | 3476 | 98.387 | 9680 | 2.83 |
| Total | 18280 | 18740 | 19460 | 18360 | 18360 | 18640 | 492.138 | 242200 | 2.64 |
| Total weight | 37320 | 38540 | 37640 | 36860 | 36540 | 37380 | | | |
| Error | 1.8489 | 4.9559 | 2.6833 | 0.624 | 0.2463 | 2.0064 | | | |

Dif. between North and South

| | | | | |
|---|---|---|---|---|
| 0.8861 | 1.5785 | 1.7367 | 0.9819 | -0.021 |

Scale:PAT without boards

date: 5-22-92

Vehicle: Blue Tractor lowboy

Total Weight West 36600 Total Weight East: 36660 Average 36630

Direction: south

| Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9820 | 9800 | 9820 | 9760 | 9760 | 9792 | 30.332 | 920 | 0.31 |
| 2 | 7720 | 7920 | 7940 | 7580 | 7920 | 7816 | 159.625 | 25480 | 2.042 |
| 3 | 7720 | 7600 | 8080 | 7440 | 7800 | 7728 | 238.998 | 57120 | 3.093 |
| 4 | 6660 | 6500 | 6640 | 6500 | 6520 | 6564 | 79.246 | 6280 | 1.207 |
| 5 | 6560 | 6820 | 6600 | 6640 | 6560 | 6636 | 108.074 | 11680 | 1.629 |
| Total | 38480 | 38640 | 39080 | 37920 | 38560 | 38536 | 415.307 | 172480 | 1.078 |
| Error | 4.8077 | 5.2019 | 6.2692 | 3.4019 | 5.0052 | 4.946 | | | |

Direction: north

| Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9740 | 10360 | 9800 | 9840 | 9620 | 9872 | 285.167 | 81320 | 2.889 |
| 2 | 7780 | 7920 | 8260 | 7720 | 7940 | 7924 | 209.476 | 43880 | 2.644 |
| 3 | 7880 | 7720 | 7760 | 7600 | 7560 | 7704 | 128.374 | 16480 | 1.666 |
| 4 | 6240 | 6420 | 6480 | 6380 | 6600 | 6424 | 132.212 | 17480 | 2.058 |
| 5 | 6500 | 6780 | 6840 | 6640 | 6520 | 6656 | 151.921 | 23080 | 2.282 |
| Total | 38140 | 39200 | 39140 | 38180 | 38240 | 38580 | 540.185 | 291800 | 1.4 |
| Error | 3.9591 | 6.5561 | 6.4129 | 4.0597 | 4.2103 | 5.0544 | | | |

Dif. between North-South

| | | | | |
|---|---|---|---|---|
| 0.8486 | 1.354 | 0.144 | 0.658 | 0.795 |

Scale:Single axle
date: 5-22-92
Vehicle: 4 axles-GMC
Total Weight West 48300 Total Weight East: 48340 Average 48320

Direction: south

| Right: Front Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7940 | 7920 | 7900 | 7880 | 7960 | 7920 | 31.623 | 1000 | 0.399 |
| 2 | 6960 | 7040 | 7000 | 7020 | 6940 | 6992 | 41.473 | 1720 | 0.593 |
| 3 | 6268 | 5920 | 5960 | 6060 | 5860 | 6013.6 | 159.765 | 25525 | 2.657 |
| 4 | 4180 | 3980 | 3920 | 4040 | 3700 | 3964 | 176.295 | 31080 | 4.447 |
| Total | 25348 | 24860 | 24780 | 25000 | 24460 | 24890 | 323.946 | 104941 | 1.302 |

| Left: Front Wheel | Run | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7920 | 7900 | 7920 | 7920 | 7760 | 7884 | 69.857 | 4880 | 0.886 |
| 2 | 6820 | 6820 | 6820 | 6840 | 6700 | 6800 | 56.569 | 3200 | 0.832 |
| 3 | 6240 | 5900 | 5880 | 5980 | 5880 | 5976 | 153.232 | 23480 | 2.564 |
| 4 | 4040 | 3840 | 3820 | 3880 | 3760 | 3868 | 105.451 | 11120 | 2.726 |
| Total | 25020 | 24460 | 24440 | 24620 | 24100 | 24528 | 333.946 | 111520 | 1.361 |
| Total weight | 50368 | 49320 | 49220 | 49620 | 48560 | 49418 | | | |
| Error | 4.0661 | 2.0276 | 1.8285 | 2.6199 | 0.4942 | 2.2211 | | | |

Direction: north

| Right: Front Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7880 | 7840 | 7840 | 7500 | 7860 | 7784 | 159.625 | 25480 | 2.051 |
| 2 | 7200 | 7180 | 6980 | 7100 | 7220 | 7136 | 98.387 | 9680 | 1.379 |
| 3 | 5680 | 6140 | 5680 | 5740 | 5440 | 5736 | 253.535 | 64280 | 4.42 |
| 4 | 4580 | 4500 | 4560 | 4800 | 4480 | 4584 | 127.593 | 16280 | 2.783 |
| Total | 25340 | 25660 | 25060 | 25140 | 25000 | 25240 | 267.582 | 71600 | 1.06 |

| Left: Front Wheel | Run 1 | 2 | 3 | 4 | 5 | Mean | Stand | Var | Cov |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7420 | 4420 | 7460 | 7440 | 7560 | 6860 | 1365.064 | 1.9E+06 | 19.9 |
| 2 | 6840 | 6880 | 6860 | 6860 | 7240 | 6936 | 170.529 | 29080 | 2.459 |
| 3 | 5640 | 6040 | 5680 | 5640 | 5780 | 5756 | 168.760 | 28480 | 2.932 |
| 4 | 4260 | 4240 | 4200 | 4420 | 4280 | 4280 | 83.666 | 7000 | 1.955 |
| Total | 24160 | 21580 | 24200 | 24360 | 24860 | 23832 | 1289.387 | 1.7E+06 | 5.41 |
| Total weight | 49500 | 47240 | 49260 | 49500 | 49860 | 49072 | | | |
| Error | 2.3838 | 2.2862 | 1.9082 | 2.3838 | 3.0886 | 1.5324 | | | |

Dif. between North-South

| | | | | |
|---|---|---|---|---|
| 1.6822 | 0.259 | 0.080 | 0.236 | 2.594 |

| DATE | VEH | DIR | BOARDS | SCALE | WEIGHT | R1 | R2 | R3 | R4 | R5 | MEAN | STD. DEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05/21/92 | GMC | S | | SAS | 48320 | 49520 | 49480 | 49240 | 49540 | 49440 | 49444 | 120.33 |
| 05/21/92 | GMC | N | | SAS | 48320 | 49140 | 49040 | 48980 | 49020 | 48940 | 49024 | 75.37 |
| 05/22/92 | GMC | S | | SAS | 48320 | 50368 | 49320 | 49220 | 49620 | 48560 | 49418 | 657.32 |
| 05/22/92 | GMC | N | | SAS | 48320 | 49500 | 47240 | 49260 | 49500 | 49860 | 49072 | 1046.29 |
| 05/22/92 | GMC | S | | PAT | 48320 | 55440 | 55440 | 54980 | 55440 | 55680 | 55396 | 254.72 |
| 05/22/92 | GMC | N | | PAT | 48320 | 54880 | 55360 | 55500 | 54380 | 54820 | 54988 | 450.02 |
| 05/22/92 | GMC | S | WB | PAT | 80700 | 82220 | 81940 | 81960 | 81960 | 80520 | 81720 | 680.73 |
| 05/22/92 | GMC | N | WB | PAT | 80700 | 81280 | 81540 | 80820 | 81260 | 81540 | 81288 | 294.48 |
| 05/22/92 | GMC | S | WB | PAT | 80700 | 88860 | 89100 | 88260 | 87160 | 86040 | 87884 | 1274.47 |
| 05/22/92 | GMC | N | WB | PAT | 80700 | 87520 | 83400 | 88580 | 88820 | 88340 | 87332 | 2251.87 |
| 05/22/92 | BLUE T | S | WB | PAT | 69070 | 70240 | 69420 | 69880 | 69320 | 69540 | 69680 | 377.62 |
| 05/22/92 | BLUE T | N | WB | PAT | 69070 | 69320 | 68960 | 69620 | 69680 | 70200 | 69556 | 459.65 |
| 05/22/92 | BLUE T | S | WB | PAT | 69070 | 71800 | 71740 | 70820 | 71100 | 71240 | 71340 | 421.19 |
| 05/22/92 | BLUE T | N | WB | PAT | 69070 | 70080 | 71340 | 70580 | 71980 | 71700 | 71136 | 789.99 |
| 05/21/92 | TRACT | S | WB | PAT | 36630 | 37200 | 37140 | 37120 | 37460 | 37600 | 37304 | 214.20 |
| 05/21/92 | TRACT | N | WB | PAT | 36630 | 36740 | 37300 | 37300 | 37020 | 36720 | 37016 | 285.10 |
| 05/22/92 | TRACT | S | WB | PAT | 36630 | 37660 | 36980 | 36860 | 37360 | 38080 | 37388 | 499.72 |
| 05/22/92 | TRACT | N | WB | PAT | 36630 | 37320 | 38540 | 37640 | 36860 | 36540 | 37380 | 773.43 |
| 05/22/92 | TRACT | S | WB | PAT | 36630 | 38480 | 38640 | 39080 | 37920 | 38560 | 38536 | 415.31 |
| 05/22/92 | TRACT | N | WB | PAT | 36630 | 38140 | 39200 | 39140 | 38180 | 38240 | 38580 | 540.19 |

Data by direction

| DATE | VEH | DIR | BOARDS | SCALE | WEIGHT | R1 | R2 | R3 | R4 | R5 | MEAN | STD. DEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05/21/92 | GMC | S | | SAS | 48320 | 49520 | 49480 | 49240 | 49540 | 49440 | 49444 | |
| 05/22/92 | GMC | S | | SAS | 48320 | 50368 | 49320 | 49220 | 49620 | 48560 | 49417.6 | 445.71 |
| 05/21/92 | GMC | N | | SAS | 48320 | 49140 | 49040 | 48980 | 49020 | 48940 | 49024 | |
| 05/22/92 | GMC | N | | SAS | 48320 | 49500 | 47240 | 49260 | 49500 | 49860 | 49072 | 699.79 |
| 05/22/92 | GMC | S | | PAT | 48320 | 55440 | 55440 | 54980 | 55440 | 55680 | 55396 | 254.72 |
| 05/22/92 | GMC | N | | PAT | 48320 | 54880 | 55360 | 55500 | 54380 | 54820 | 54988 | 450.02 |
| 05/22/92 | GMC | S | WB | PAT | 80700 | 82220 | 81940 | 81960 | 81960 | 80520 | 81720 | |
| 05/22/92 | GMC | S | WB | PAT | 80700 | 88860 | 89100 | 88260 | 87160 | 86040 | 87884 | 3388.51 |
| 05/22/92 | GMC | N | WB | PAT | 80700 | 81280 | 81540 | 80820 | 81260 | 81540 | 81288 | |
| 05/22/92 | GMC | N | WB | PAT | 80700 | 87520 | 83400 | 88580 | 88820 | 88340 | 87332 | 3526.97 |
| 05/22/92 | BLUE T | S | WB | PAT | 69070 | 70240 | 69420 | 69880 | 69320 | 69540 | 69680 | |
| 05/22/92 | BLUE T | S | WB | PAT | 69070 | 71800 | 71740 | 70820 | 71100 | 71240 | 71340 | 952.72 |
| 05/22/92 | BLUE T | N | WB | PAT | 69070 | 69320 | 68960 | 69620 | 69680 | 70200 | 69556 | |
| 05/22/92 | BLUE T | N | WB | PAT | 69070 | 70080 | 71340 | 70580 | 71980 | 71700 | 71136 | 1031.85 |
| 05/21/92 | TRACT | S | WB | PAT | 36630 | 37200 | 37140 | 37120 | 37460 | 37600 | 37304 | |
| 05/22/92 | TRACT | S | WB | PAT | 36630 | 37660 | 36980 | 36860 | 37360 | 38080 | 37388 | |
| 05/22/92 | TRACT | S | WB | PAT | 36630 | 38480 | 38640 | 39080 | 37920 | 38560 | 38536 | 687.14 |
| 05/21/92 | TRACT | N | WB | PAT | 36630 | 36740 | 37300 | 37300 | 37020 | 36720 | 37016 | |
| 05/22/92 | TRACT | N | WB | PAT | 36630 | 37320 | 38540 | 37640 | 36860 | 36540 | 37380 | |
| 05/22/92 | TRACT | N | WB | PAT | 36630 | 38140 | 39200 | 39140 | 38180 | 38240 | 38580 | 869.43 |

TEST #1
Ho: the variance of the two population are equal
H1: the variance are not equal

Group #1
Pooled variance

| | | |
|---|---|---|
| Sp^2 = | 3E+05 | 2E+05 |
| q = | 0.77 | 5E+05 |
| h = | 1.056 | 7E+05 |
| b = | 1.679 | 0.711 |
| alpha = | 0.05 | |
| nu = | 1 | |
| B = | 3.841 | page 461 |

b < B, then
Conclusion: The variance of the two population are equal

Group #2
Pooled variance

| | | |
|---|---|---|
| Sp^2 = | 133700 | |
| q = | 0.5347 | |
| h = | 1.125 | |
| b = | 1.0945 | |
| alpha = | 0.05 | |
| nu = | 1 | |
| B = | 3.841 | page 461 |

b < B, then
Conclusion: The variances are equal

Group #3
Pooled variance

| | | |
|---|---|---|
| Sp^2 = | 1E+07 | |
| q = | 0.006 | |
| h = | 1.056 | |
| b = | 0.014 | |
| alpha = | 0.05 | |
| nu = | 1 | |
| B = | 3.841 | page 461 |

b < B, then
Conclusion: The variance of the two population are equal

Group #4
Pooled variance

| | | |
|---|---|---|
| Sp^2 = | 986191 | |
| q = | 0.0249 | |
| h = | 1.0556 | |
| b = | 0.0542 | |
| alpha = | 0.05 | |
| nu = | 1 | |
| B = | 3.841 | page 461 |

b < B, then
Conclusion: The variances are equal

Group #5
Pooled variance

| | | |
|---|---|---|
| Sp^2 = | 7E+06 | |
| q = | 29.91 | |
| h = | 1.036 | |
| b = | 66.49 | |
| alpha = | 0.05 | |
| nu = | 1 | |
| B = | 3.841 | page 461 |

b < B, then
Conclusion: The variance of the two population are equal

TEST #2

Ho: The samples means are equal

H1: at least two of the means are not equal

| | | | |
|---|---|---|---|
| alpha= | 0.05 | | |
| nu1 = | 1 | 1 | 1 |
| nu2 = | 9 | 4 | 14 |
| F | 5.12 | 7.7 | 4.6 |

Anova: Group 1

| Source of variation | Sum of Squares | Degree of freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Treatments | 7E+05 | 1 | 732679 | 2.1287 |
| Error | 6E+06 | 18 | 344183 | |
| Total | 7E+06 | 19 | | |

Conclusion: f < F the sample have equal mean

Anova: Group 2

| Source of variation | Sum of Squares | Degree of freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Treatments | 4E+05 | 1 | 416160 | 3.1126 |
| Error | 1E+06 | 8 | 133700 | |
| Total | 1E+06 | 9 | | |

Conclusion: f < F the sample have equal mean

Anova: Group 3

| Source of variation | Sum of Squares | Degree of freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Treatments | 1E+06 | 1 | 1E+06 | 0.1012 |
| Error | 2E+08 | 18 | 1E+07 | |
| Total | 2E+08 | 19 | | |

Conclusion: f < F the sample have equal mean

Anova: Group 4

| Source of variation | Sum of Squares | Degree of freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Treatments | 1E+05 | 1 | 134480 | 0.1364 |
| Error | 2E+07 | 18 | 986191 | |
| Total | 2E+07 | 19 | | |

Conclusion: f < F the sample have equal mean

Anova: Group 1

| Source of variation | Sum of Squares | Degree of freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Treatments | 52920 | 1 | 52920 | 0.0862 |
| Error | 2E+07 | 28 | 614038 | |
| Total | 2E+07 | 29 | | |

Conclusion: f < F the sample have equal mean

TEST #3
Checking if exist any different between SSA and PAT

Pooled variance

| | | |
|---|---|---|
| Sp^2 = | 7E+06 | |
| q = | 39 | |
| h = | 1.043 | |
| b = | 86.12 | |
| alpha = | 0.05 | |
| nu = | 1 | |
| B = | 3.841 | page 461 |

b > B, then
Conclusion: The variance of the two scales are not equal

TEST #4
A 95% confidence intervals for the mean
alpha = 0.05

| Group | mean | n | nu | s | t | Confidence interval | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 49239 | 20 | 19 | 603.8 | 2.093 | 48957 | <Mean< | 49522 |
| 2 | 55192 | 10 | 9 | 406.3 | 2.262 | 54901 | <Mean< | 55483 |
| 3 | 84556 | 20 | 19 | 3376 | 2.093 | 82976 | <Mean< | 86136 |
| 4 | 70428 | 20 | 19 | 970.2 | 2.093 | 69974 | <Mean< | 70882 |
| 5 | 37701 | 30 | 29 | 771.2 | 2.045 | 37413 | <Mean< | 37989 |

A 95% confidence intervals for the variance of a normal population

| Group | n | n-1 | s^2 | X0.025 | X0.975 | Confidence interval | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 19 | 4E+05 | 32.85 | 8.907 | 210884 | < V^2 < | 777813 |
| 2 | 10 | 9 | 2E+05 | 19.02 | 2.7 | 78103 | < V^2 < | 550281 |
| 3 | 20 | 19 | 1E+07 | 32.85 | 8.907 | 7E+06 | < V^2 < | 2E+07 |
| 4 | 20 | 19 | 9E+05 | 32.85 | 8.907 | 544439 | < V^2 < | 2E+06 |
| 5 | 30 | 29 | 6E+05 | 45.72 | 16.047 | 377192 | < V^2 < | 1E+06 |

TEST #5: Cochran's test

1. Ho: the variance of the two population are equal
2. H1: the variance are not equal
3. alpha = 0.05
4. Critical Region: G find in table XI, page 473

5. Computations:

| Group | alpha | n | S (l)^ | S (u)^ | S total | g | G | Conclusion |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.05 | 10 | 2E+05 | 5E+05 | 688366 | 0.7114 | 0.801 | Equal variance between north and south dir. |
| 2 | 0.05 | 5 | 64880 | 2E+05 | 267400 | 0.7574 | 0.9057 | Equal variance between north and south dir. |
| 3 | 0.05 | 10 | 1E+07 | 1E+07 | 2E+07 | 0.52 | 0.801 | Equal variance between north and south dir. |
| 4 | 0.05 | 10 | 9E+05 | 1E+06 | 2E+06 | 0.5398 | 0.801 | Equal variance between north and south dir. |
| 5 | 0.05 | 15 | 5E+05 | 8E+05 | 1E+06 | 0.6155 | 0.7521 | Equal variance between north and south dir. |

# APPENDIX B

## EXAMPLE OF THE FORM USED TO WRITE THE DATA

This form is an example of the data sheet used to write the weight measurements and other information for the 3-axle vehicles, GMC truck.

P.A.T. SCALE DATA

DATE: ____________ VEHICLE: ____________
TIME: ____________ AXLES: ____________
TEMP: ____________ BLOCKS: ____________
CONDITION: ____________ DRIVER: ____________
TIRE PRESSURE: ____________

| | AXLES | | |
|---|---|---|---|
| RUN | 1 | 2 | 3 |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |
| 19 | | | |
| 20 | | | |
| 21 | | | |
| 22 | | | |
| 23 | | | |
| 24 | | | |
| 25 | | | |
| 26 | | | |
| 27 | | | |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| NOTES: | | | |

## APPENDIX C

## PAT SAMPLES PARAMETERS

### C.1 INTRODUCTION.

All the information from the field test is summarized in this appendix. The data display is similar to the data form used in the field (see Appendix B). The information includes date, time, temperature, weather condition, vehicle type, number of axles, type of block used for loading the vehicle (lead or steel), amount of load, driver weight, and tire pressure. The Mississippi scale data are the EAST and WEST weight entries, and the total gross weight used is the average between both (average weight). For each vehicle the mean, standard deviation, covariance, percent of error, maximum, and minimum were calculated. The sample mean and variance were compared with the evaluated using the test of hypothesis. Cochran's test was used to compare the variance between the loaded and unloaded condition. The ANOVA test compared the mean between both loaded and unloaded samples.

### C.2 DEFINITIONS.

Some equations and definitions used in the text and calculations are shown below:

Sample mean ($\mu_s$) - a value which is typical or representative of a set of data. This typical value is known as the measure of central tendency because it tends to lie centrally within a set of data arranged according to magnitude.

$$\mu_s = \frac{X_1+X_2+X_3+\ldots+X_j}{n} \tag{C.1}$$

where
- $X_j$ = weight observed on the scale, j = 1 to n
- n = total number of observations

Population mean ($\mu$) - a value which is typical or representative of the entire population. This typical value is known as the measure of central tendency because it tends to lie centrally within the population arranged according to magnitude.

$$\mu = \frac{X_1+X_2+X_3+\ldots+X_j}{n=\infty} \tag{C.2}$$

where
- $X_j$ = weight observed in the scale, j = 1 to n
- n = total number of observations

Variation or dispersion - the degree by which the numerical data tends to spread about the mean.

Dispersion (d) - the difference between what has been expected or predetermined and what actually occurs.

$$d = X_j - \mu_s \tag{C.3}$$

where
$X_j$ = weight observed in the scale
$\mu_s$ = sample mean weight

Sample standard deviation (s) - measure of dispersion or variation for a sample drawn from a specific population.

$$s = \sqrt{\frac{\Sigma(X_j - \mu_s)^2}{n-1}} = \sqrt{\frac{\Sigma(d)^2}{n-1}} \tag{C.4}$$

where
d = deviation
n = total number of observations

Population standard deviation ($\sigma$)- measure of dispersion or variation for a specific population.

$$\sigma = \sqrt{\frac{\Sigma(X_j - \mu_s)^2}{n}} = \sqrt{\frac{\Sigma(d)^2}{n}} \tag{C.5}$$

Sample variance ($s^2$) - the square of the sample's standard deviation, which is the mean square of the deviation from the sample mean.

$$s^2 = \frac{\Sigma(X_j - \mu_s)^2}{n-1} = \frac{\Sigma(d)^2}{n-1} \tag{C.6}$$

Population variance ($\sigma^2$) - the square of the population's standard deviation, which is the mean square of the deviation from the population mean.

$$\sigma^2 = \frac{\Sigma(X_j - \mu_s)^2}{n} = \frac{\Sigma(d)^2}{n} \tag{C.7}$$

Range - the difference between the largest and smallest number in the set. It could be indicated as A to B, or simply A-B.

Error (e) - the difference between what has been expected or predetermined and what actually occurs divided by the expected. If percent of error is desired then multiply by 100.

$$e = \frac{(\mu - \mu_s)}{\mu} \tag{C.8}$$

## C.3 TEST OF HYPOTHESIS.

The test of hypothesis is an assertion or conjecture concerning one or more populations. Sample parameters such as variance, mean, and correlation coefficients are tested to determine the validity associated with using the values to make inference about the population.

Part of this procedure is specifying the set of values for the statistics test (t or z) which leads to rejection of $H_o$. This set of values is called the critical region or rejection region for the test. The rejection region implies that a sample can be used to make inferences about population parameters, distributions, and other characteristics that describe the population.

The test of hypotheses is described as:

1. Null hypothesis, $H_o$: $\mu_s = \mu$
2. Alternative hypothesis, $H_a$: $\mu_s \neq \mu$
3. Statistics test such $t$ or $z$
4. Rejection region
5. Conclusion

The following pages show the vehicle weight using the PAT and Mississippi scales. Also, the result for each sample parameter and the test of hypothesis to compare the samples and the population. The first test of hypothesis evaluate the sample mean with the population mean. The second compares the sample and population variance using Cochran's test. The last test, ANOVA, compares the sample mean to the load conditions.

**P.A.T. SCALE DATA: GMC/ARMY TRUCK (Load)**

DATE:06/23/92
TIME:01:05 PM
TEMP (F):101
CONDITION:SUNNY & HUMID

M.S. EAST WGHT:80920 lb
M.S. WEST WGHT:80860 lb

VEHICLE: GMC/ARMY TRUCK
AXLES: 4
BLOCKS: 16 LEAD
DRIVER: 206, lb
TIRE PRESS.: SELF-INFLATED
AVG. WEIGHT: 80890 lb

| | AXLES' WEIGHT, lb | | | | TOTAL | |
|---|---|---|---|---|---|---|
| RUN: | 1 | 2 | 3 | 4 | WEIGHT | ERROR |
| 1 | 19780 | 18980 | 20660 | 21060 | 80480 | -0.0051 |
| 2 | 19960 | 18980 | 20820 | 20260 | 80020 | -0.0108 |
| 3 | 20060 | 19340 | 21480 | 19940 | 80820 | -0.0009 |
| 4 | 19960 | 18940 | 21460 | 19920 | 80280 | -0.0075 |
| 5 | 19900 | 18800 | 21300 | 20540 | 80540 | -0.0043 |
| 6 | 19860 | 18760 | 21580 | 20680 | 80880 | -0.0001 |
| 7 | 19820 | 18720 | 21360 | 20720 | 80620 | -0.0033 |
| 8 | 19840 | 18760 | 20720 | 20760 | 80080 | -0.0100 |
| 9 | 19960 | 18800 | 21180 | 20520 | 80460 | -0.0053 |
| 10 | 19880 | 18720 | 21240 | 20520 | 80360 | -0.0066 |
| 11 | 19820 | 18840 | 21000 | 20440 | 80100 | -0.0098 |
| 12 | 19840 | 18640 | 21200 | 20540 | 80220 | -0.0083 |
| 13 | 19860 | 18660 | 21480 | 20560 | 80560 | -0.0041 |
| 14 | 19820 | 18580 | 21080 | 20400 | 79880 | -0.0125 |
| 15 | 19740 | 18660 | 21240 | 20420 | 80060 | -0.0103 |
| 16 | 19740 | 18540 | 21200 | 20560 | 80040 | -0.0105 |
| 17 | 19920 | 18740 | 21360 | 20620 | 80640 | -0.0031 |
| 18 | 19820 | 18740 | 21260 | 20700 | 80520 | -0.0046 |
| 19 | 19700 | 18540 | 21040 | 20380 | 79660 | -0.0152 |
| 20 | 19700 | 18780 | 21340 | 20600 | 80420 | -0.0058 |
| 21 | 19660 | 18520 | 21300 | 20420 | 79900 | -0.0122 |
| 22 | 19740 | 18740 | 21240 | 20420 | 80140 | -0.0093 |
| 23 | 19880 | 18780 | 21100 | 20660 | 80420 | -0.0058 |
| 24 | 19720 | 18340 | 21340 | 20320 | 79720 | -0.0145 |
| 25 | 19600 | 18640 | 21200 | 20420 | 79860 | -0.0127 |
| 26 | 19840 | 18800 | 21100 | 20540 | 80280 | -0.0075 |
| 27 | 19780 | 18800 | 21220 | 20520 | 80320 | -0.0070 |
| 28 | 19800 | 18700 | 21220 | 20500 | 80220 | -0.0083 |
| 29 | 19760 | 18640 | 21320 | 20580 | 80300 | -0.0073 |
| 30 | 19740 | 18560 | 21380 | 20540 | 80220 | -0.0083 |
| Max. | 20060 | 19340 | 21580 | 21060 | 80880 | |
| Min. | 19600 | 18340 | 20660 | 19920 | 79660 | |

| | | |
|---|---|---|
| TOTAL | 2408020 | -0.2309 |
| MEAN | 80267.333 | -0.0077 |
| STANDARD | 303.47338 | 0.0038 |
| VARIANCE | 92096.092 | 0.0000 |
| COVARIANCE | 0.378 | -48.7377 |
| % ERROR | 0.770 | |

## P.A.T. SCALE DATA: GMC/ARMY TRUCK (Half-load)

DATE: 06/25/92
TIME: 07:30 AM
TEMP (F): 87
CONDITION: SUNNY & HUMID

VEHICLE: GMC/ARMY TRUCK
AXLES: 4
BLOCKS: 8 LEAD
DRIVER: 210, lb
TIRE PRESS.: SELF-INFLATED

EAST WGHT: 64720 lb
WEST WGHT: 64680 lb
AVG. WEIGHT: 64700 lb

| | AXLES' WEIGHT, lb | | | | TOTAL | |
|---|---|---|---|---|---|---|
| RUN: | 1 | 2 | 3 | 4 | WEIGHT | ERROR |
| 1 | 18200 | 16180 | 15880 | 14380 | 64640 | -0.0009 |
| 2 | 18160 | 16220 | 15800 | 14380 | 64560 | -0.0022 |
| 3 | 18120 | 16200 | 15780 | 14340 | 64440 | -0.0040 |
| 4 | 18060 | 16180 | 15760 | 14360 | 64360 | -0.0053 |
| 5 | 18240 | 16240 | 15840 | 14260 | 64580 | -0.0019 |
| 6 | 18120 | 16160 | 15820 | 14280 | 64380 | -0.0049 |
| 7 | 18100 | 16220 | 15780 | 14320 | 64420 | -0.0043 |
| 8 | 18080 | 16120 | 15780 | 14340 | 64320 | -0.0059 |
| 9 | 18160 | 16220 | 15860 | 14260 | 64500 | -0.0031 |
| 10 | 18120 | 16200 | 15880 | 14340 | 64540 | -0.0025 |
| 11 | 18160 | 16220 | 15740 | 14280 | 64400 | -0.0046 |
| 12 | 18180 | 16140 | 15840 | 14360 | 64520 | -0.0028 |
| 13 | 18080 | 16140 | 15840 | 14320 | 64380 | -0.0049 |
| 14 | 18100 | 16180 | 15860 | 14380 | 64520 | -0.0028 |
| 15 | 18140 | 16120 | 15780 | 14320 | 64360 | -0.0053 |
| 16 | 18140 | 16160 | 15820 | 14320 | 64440 | -0.0040 |
| 17 | 18160 | 16200 | 15840 | 14380 | 64580 | -0.0019 |
| 18 | 18100 | 16120 | 15680 | 14300 | 64200 | -0.0077 |
| 19 | 18140 | 16160 | 15800 | 14400 | 64500 | -0.0031 |
| 20 | 18140 | 16120 | 15720 | 14420 | 64400 | -0.0046 |
| 21 | 18160 | 16160 | 15840 | 14340 | 64500 | -0.0031 |
| 22 | 18160 | 16120 | 15780 | 14280 | 64340 | -0.0056 |
| 23 | 18080 | 16200 | 15600 | 14340 | 64220 | -0.0074 |
| 24 | 18120 | 16140 | 15680 | 14320 | 64260 | -0.0068 |
| 25 | 18120 | 16100 | 15760 | 14320 | 64300 | -0.0062 |
| 26 | 18120 | 16120 | 15720 | 14280 | 64240 | -0.0071 |
| 27 | 18140 | 16100 | 15780 | 14360 | 64380 | -0.0049 |
| 28 | 18220 | 16140 | 15720 | 14340 | 64420 | -0.0043 |
| 29 | 18180 | 16080 | 15820 | 14340 | 64420 | -0.0043 |
| 30 | 18140 | 16120 | 15740 | 14320 | 64320 | -0.0059 |
| Max. | 18240 | 16240 | 15880 | 14420 | 64640 | |
| Min. | 18060 | 16080 | 15600 | 14260 | 64200 | |

| | | |
|---|---|---|
| TOTAL | 1932440 | -0.1323 |
| MEAN | 64414.667 | -0.0044 |
| STANDARD | 113.37254 | 0.0018 |
| VARIANCE | 12853.333 | 0.0000 |
| COVARIANCE | 0.176 | -39.7334 |
| % ERROR | 0.441 | |

**TEST #1**

**GMC truck load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: -Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = -11.23821

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**GMC truck half load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = -13.78495

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**TEST #2: Cochran's test**

1. Ho: The variances of the load and unload samples are equal
2. H1: The variances of the load and unload samples are not equal

3. alpha = 0.05
4. Critical Region: G = 0.686065

| | |
|---|---|
| 17 | 0.7341 |
| 30 | x |
| 37 | 0.6602 |
| x = | 0.686065 |

5. Computations:

| | |
|---|---|
| S load^2 = | 92096.092 |
| S unload^2 = | 12853.333 |
| S total = | 104949.43 |
| g = | 0.1224717 > G then, |

6. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the load and unload samples' variance

**TEST #3: ANOVA**

1. Ho: The load and the unload samples' mean are equal

2. H1: The load and the unload samples' mean are not equal

3. alpha = 0.05
4. Degrees of freedom
   nu 1 = # samples - 1 = 1
   nu 2 = # samples(sample size - 1) = 58

5. Critical region: F > 4.008

| | |
|---|---|
| 40 | 4.08 |
| 58 | x |
| 60 | 4 |
| x = | 4.008 |

6. Computations:

| Source of variation | Sum of Squares | Degree of Freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Aggregates | 3.77E+09 | 1 | 3769605606.7 | 71836.6> F then, |
| Error | 3043533.3 | 58 | 52474.7 | |
| Total | 3.773E+09 | 59 | | |

7. Conclusion: Reject Ho and conclude that the samples do not have the same mean

## P.A.T. SCALE DATA: GMC/ARMY TRUCK (Load)

**SPECIAL-TEST:LEVELS ONLY UNDER AXLES NEXT TO SCALES**

DATE:06/23/92
TIME:03:32 PM
TEMP (F):118
CONDITION:EXTREME HOT

VEHICLE: GMC/ARMY TRUCK
AXLES: 4
BLOCKS: 16 LEAD
DRIVER: 206, lb
TIRE PRESS.: SELF INFLATED
AVG. WEIGHT:80890 lb

EAST WGHT:80920 lb
WEST WGHT:80860 lb

| | AXLES' WEIGHT, lb | | | | TOTAL | |
|---|---|---|---|---|---|---|
| RUN: | 1 | 2 | 3 | 4 | WEIGHT | ERROR |
| 1 | 19560 | 18560 | 22300 | 20040 | 80460 | -0.0053 |
| 2 | 19540 | 18660 | 21820 | 20120 | 80140 | -0.0093 |
| 3 | 19540 | 18720 | 21440 | 19940 | 79640 | -0.0155 |
| 4 | 19480 | 18420 | 21640 | 19880 | 79420 | -0.0182 |
| 5 | 19440 | 18680 | 21680 | 20100 | 79900 | -0.0122 |
| 6 | 19520 | 18620 | 21440 | 19840 | 79420 | -0.0182 |
| 7 | 19420 | 18480 | 21820 | 20080 | 79800 | -0.0135 |
| 8 | 19520 | 18740 | 21780 | 20020 | 80060 | -0.0103 |
| 9 | 19440 | 18200 | 21840 | 19880 | 79360 | -0.0189 |
| 10 | 19500 | 18540 | 21860 | 19980 | 79880 | -0.0125 |
| 11 | 19640 | 18740 | 21540 | 20060 | 79980 | -0.0112 |
| 12 | 19380 | 18660 | 21740 | 19980 | 79760 | -0.0140 |
| 13 | 19460 | 18520 | 21820 | 20000 | 79800 | -0.0135 |
| 14 | 19400 | 18420 | 21760 | 19960 | 79540 | -0.0167 |
| 15 | 19520 | 18500 | 21260 | 20020 | 79300 | -0.0197 |
| Max. | 19640 | 18740 | 22300 | 20120 | 80460 | |
| Min. | 19380 | 18200 | 21260 | 19840 | 79300 | |
| | | | | TOTAL | 1196460 | -0.2088 |
| | | | | MEAN | 79764 | -0.0139 |
| | | | | STANDARD | 324.62726 | 0.0040 |
| | | | | VARIANCE | 105382.86 | 0.0000 |
| | | | | COVARIANCE | 0.407 | -28.8301 |
| | | | | % ERROR | 1.392 | |

## P.A.T. SCALE DATA: GMC/ARMY TRUCK (Half-load)

**SPECIAL-TEST:LEVELS ONLY UNDER AXLES NEXT TO SCALES**

DATE:06/24/92
TIME:04:35 PM
TEMP (F):111
CONDITION:SUNNY & HOT

EAST WGHT:64720 lb
WEST WGHT:64680 lb

VEHICLE: GMC/ARMY TRUCK
AXLES: 4
BLOCKS: 8 LEAD
DRIVER: 210, lb
TIRE PRESS.: SELF INFLATED
AVG. WEIGHT:64700 lb

| | AXLES' WEIGHT, lb | | | | TOTAL | |
|---|---|---|---|---|---|---|
| RUN: | 1 | 2 | 3 | 4 | WEIGHT | ERROR |
| 1 | 17900 | 16040 | 15960 | 13940 | 63840 | -0.0133 |
| 2 | 17700 | 16300 | 15900 | 13980 | 63880 | -0.0127 |
| 3 | 17800 | 16180 | 16040 | 13980 | 64000 | -0.0108 |
| 4 | 17740 | 16200 | 15960 | 14000 | 63900 | -0.0124 |
| 5 | 17640 | 16180 | 15880 | 13860 | 63560 | -0.0176 |
| 6 | 17740 | 16200 | 15980 | 13860 | 63780 | -0.0142 |
| 7 | 17560 | 16200 | 16140 | 13960 | 63860 | -0.0130 |
| 8 | 17820 | 16200 | 16040 | 13980 | 64040 | -0.0102 |
| 9 | 17820 | 16040 | 16040 | 13980 | 63880 | -0.0127 |
| 10 | 17860 | 16220 | 16020 | 13980 | 64080 | -0.0096 |
| 11 | 17820 | 16260 | 16000 | 14020 | 64100 | -0.0093 |
| 12 | 17840 | 16120 | 15980 | 13900 | 63840 | -0.0133 |
| 13 | 17680 | 16320 | 16000 | 13980 | 63980 | -0.0111 |
| 14 | 17880 | 16240 | 15900 | 13960 | 63980 | -0.0111 |
| 15 | 17820 | 16080 | 16040 | 14000 | 63940 | -0.0117 |
| Max. | 17900 | 16320 | 16140 | 14020 | 64100 | |
| Min. | 17560 | 16040 | 15880 | 13860 | 63560 | |

| | | |
|---|---|---|
| TOTAL | 958660 | -0.1830 |
| MEAN | 63910.667 | -0.0122 |
| STANDARD | 134.77318 | 0.0021 |
| VARIANCE | 18163.81 | 0.0000 |
| COVARIANCE | 0.211 | -17.0743 |
| % ERROR | 1.220 | |

**TEST #1**

**GMC truck load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 15
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = -13.4338

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**GMC truck half load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 15
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = -22.68311

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**TEST #2: Cochran's test**

1. Ho: The variances of the load and unload samples are equal
2. H1: The variances of the load and unload samples are not equal

3. alpha = 0.05
4. Critical Region: G = 0.7521

| | |
|---|---|
| 11 | 0.788 |
| 15 | x |
| 17 | 0.7341 |
| x = | 0.7520667 |

5. Computations:

| | |
|---|---|
| S load^2 = | 105382.86 |
| S unload^2 = | 18163.81 |
| S total = | 123546.67 |
| g = | 0.8529802 > G then, |

6. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the load and unload samples' variance.

**TEST #3: ANOVA**

1. Ho: The load and the unload samples' mean are equal

2. H1: The load and the unload samples' mean are not equal

3. alpha = 0.05
4. Degrees of freedom
   nu 1 = # samples - 1 = 1
   nu 2 = # samples(sample size - 1) = 28

5. Critical region: F > 4.20

6. Computations:

| Source of variation | Sum of Squares | Degree of Freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Aggregates | 94248067 | 1 | 942480666.7 | 0.3368 < F then, |
| Error | 7.835E+10 | 28 | 2798330258.1 | |
| Total | 7.93E+10 | 29 | | |

7. Conclusion: Accept Ho and conclude that the samples do have the same mean

# P.A.T. SCALE DATA: 6X6 ARMY TRUCK (Load)

DATE:06/23/92
TIME:10:45 AM
TEMP (F):100
CONDITION:HEAT

VEHICLE: 6X6 ARMY TRUCK
AXLES: 3
BLOCKS: 8 LEAD
DRIVER: 190, lb
TIRE PRESS.: 85 PSI
AVG. WEIGHT:35060 lb

EAST WGHT:35060 lb
WEST WGHT:35060 lb

| RUN: | AXLES' WEIGHT, lb 1 | 2 | 3 | TOTAL WEIGHT | ERROR |
|---|---|---|---|---|---|
| 1 | 8420 | 13268 | 13460 | 35148 | 0.0025 |
| 2 | 8180 | 13320 | 13860 | 35360 | 0.0086 |
| 3 | 8420 | 13040 | 13860 | 35320 | 0.0074 |
| 4 | 8360 | 13240 | 13560 | 35160 | 0.0029 |
| 5 | 8180 | 13320 | 13400 | 34900 | -0.0046 |
| 6 | 8380 | 13420 | 13580 | 35380 | 0.0091 |
| 7 | 8440 | 13360 | 13640 | 35440 | 0.0108 |
| 8 | 8000 | 13400 | 13600 | 35000 | -0.0017 |
| 9 | 8420 | 13600 | 13600 | 35620 | 0.0160 |
| 10 | 8480 | 13660 | 13580 | 35720 | 0.0188 |
| 11 | 8460 | 13520 | 13500 | 35480 | 0.0120 |
| 12 | 8460 | 13280 | 13520 | 35260 | 0.0057 |
| 13 | 8380 | 13320 | 13520 | 35220 | 0.0046 |
| 14 | 8360 | 13400 | 13600 | 35360 | 0.0086 |
| 15 | 8460 | 13580 | 13420 | 35460 | 0.0114 |
| 16 | 8440 | 13440 | 13640 | 35520 | 0.0131 |
| 17 | 8340 | 13640 | 13520 | 35500 | 0.0125 |
| 18 | 8400 | 13160 | 13540 | 35100 | 0.0011 |
| 19 | 8420 | 13400 | 13440 | 35260 | 0.0057 |
| 20 | 8400 | 13300 | 13480 | 35180 | 0.0034 |
| 21 | 8320 | 13360 | 13620 | 35300 | 0.0068 |
| 22 | 8380 | 13400 | 13440 | 35220 | 0.0046 |
| 23 | 8320 | 13640 | 13520 | 35480 | 0.0120 |
| 24 | 8460 | 13440 | 13680 | 35580 | 0.0148 |
| 25 | 8400 | 13220 | 13540 | 35160 | 0.0029 |
| 26 | 8340 | 13380 | 13780 | 35500 | 0.0125 |
| 27 | 8220 | 13240 | 13500 | 34960 | -0.0029 |
| 28 | 8420 | 13360 | 13580 | 35360 | 0.0086 |
| 29 | 8380 | 13240 | 13500 | 35120 | 0.0017 |
| 30 | 8380 | 13260 | 13540 | 35180 | 0.0034 |
| Max. | 8480 | 13660 | 13860 | 35720 | |
| Min. | 8000 | 13040 | 13400 | 34900 | |
| | | | TOTAL | 1059248 | 0.2124 |
| | | | MEAN | 35308.267 | 0.0071 |
| | | | STANDARD | 199.6768 | 0.0057 |
| | | | VARIANCE | 39870.823 | 0.0000 |
| | | | COVARIANCE | 0.566 | 80.4284 |
| | | | % ERROR | 0.708 | |

## P.A.T. SCALE DATA: 6X6 ARMY TRUCK (Half-load)

DATE: 06/24/92
TIME: 03:30 PM
TEMP (F): 121
CONDITION: EXTREME HEAT
EAST WGHT: 27160 lb
WEST WGHT: 27140 lb

VEHICLE: 6X6 ARMY TRUCK
AXLES: 3
BLOCKS: 4 LEAD
DRIVER: 190, lb
TIRE PRESS.: 89.5 PSI
AVG. WEIGHT: 27150 lb

| RUN: | AXLES' WEIGHT, lb 1 | 2 | 3 | TOTAL WEIGHT | ERROR |
|---|---|---|---|---|---|
| 1 | 8180 | 9440 | 9440 | 27060 | -0.0033 |
| 2 | 8080 | 9340 | 9480 | 26900 | -0.0092 |
| 3 | 8200 | 9300 | 9320 | 26820 | -0.0122 |
| 4 | 8240 | 9280 | 9420 | 26940 | -0.0077 |
| 5 | 8260 | 9140 | 9540 | 26940 | -0.0077 |
| 6 | 8440 | 9140 | 9360 | 26940 | -0.0077 |
| 7 | 8260 | 9320 | 9440 | 27020 | -0.0048 |
| 8 | 8360 | 9400 | 9400 | 27160 | 0.0004 |
| 9 | 8440 | 9320 | 9440 | 27200 | 0.0018 |
| 10 | 8360 | 9260 | 9480 | 27100 | -0.0018 |
| 11 | 8360 | 9280 | 9460 | 27100 | -0.0018 |
| 12 | 8320 | 9400 | 9600 | 27320 | 0.0063 |
| 13 | 8400 | 9360 | 9540 | 27300 | 0.0055 |
| 14 | 8360 | 9380 | 9380 | 27120 | -0.0011 |
| 15 | 8480 | 9280 | 9420 | 27180 | 0.0011 |
| 16 | 8460 | 9200 | 9500 | 27160 | 0.0004 |
| 17 | 8360 | 9220 | 9560 | 27140 | -0.0004 |
| 18 | 8220 | 9360 | 9420 | 27000 | -0.0055 |
| 19 | 8400 | 9280 | 9540 | 27220 | 0.0026 |
| 20 | 8380 | 9280 | 9560 | 27220 | 0.0026 |
| 21 | 8360 | 9320 | 9480 | 27160 | 0.0004 |
| 22 | 8400 | 9360 | 9500 | 27260 | 0.0041 |
| 23 | 8340 | 9380 | 9500 | 27220 | 0.0026 |
| 24 | 8380 | 9400 | 9460 | 27240 | 0.0033 |
| 25 | 8380 | 9380 | 9420 | 27180 | 0.0011 |
| 26 | 8360 | 9360 | 9480 | 27200 | 0.0018 |
| 27 | 8360 | 9400 | 9520 | 27280 | 0.0048 |
| 28 | 8380 | 9220 | 9560 | 27160 | 0.0004 |
| 29 | 8420 | 9340 | 9660 | 27420 | 0.0099 |
| 30 | 8520 | 9360 | 9660 | 27540 | 0.0144 |
| Max. | 8520 | 9440 | 9660 | 27540 | |
| Min. | 8080 | 9140 | 9320 | 26820 | |

| | | |
|---|---|---|
| TOTAL | 814500 | -0.0000 |
| MEAN | 27150 | -0.0000 |
| STANDARD | 154.54048 | 0.0057 |
| VARIANCE | 23882.759 | 0.0000 |
| COVARIANCE | 0.569 | -7.50E+18 |
| % ERROR | 0 | |

**TEST #1**

**6 X 6 army truck load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region:- Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = 6.81006788

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**6 X 6 army truck half load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region:- Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n))

7. Conclusion: Accept Ho at 0.05 level of significance. There are not significant differences between the sample and population mean

**TEST #2: Cochran's test**

1.Ho: The variances of the load and unload samples are equal
2. H1: The variances of the load and unload samples are not equal

3. alpha = 0.05
4. Critical Region: G = 0.686065

| | |
|---|---|
| 17 | 0.7341 |
| 30 | G |
| 37 | 0.6602 |
| G= | 0.686065 |

5. Computations:

S load^2 = 39870.823
S unload^2 = 23882.7586
S total = 63753.5816
g = 0.62538954 < G then,

6. Conclusion: Accept Ho at 0.05 level of significance. There are not significant differences between the load and unload samples' variance

**TEST #3: ANOVA**

1. Ho: The load and the unload samples' mean are equal

2. H1: The load and the unload samples' mean are not equal

3. alpha = 0.05
4. Degrees of freedom
   nu 1 = # samples - 1 = 1
   nu 2 = # samples(sample size - 1) = 58

5. Critical region: F > 4.008

| | |
|---|---|
| 40 | 4.08 |
| 58 | x |
| 60 | 4 |
| x = | 4.008 |

6. Computations:

| Source of variation | Sum of Squares | Degree of Freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Aggregates | 998359725 | 1 | 998359725.1 | 31319.33>F then, |
| Error | 1848853.87 | 58 | 31876.8 | |
| Total | 100020858 | 59 | | |

7. Conclusion: Reject Ho and conclude that the samples do not have the same mean

# P.A.T. SCALE DATA: JEEP HONCHO (Load)

DATE:06/23/92
TIME:09:46 AM
TEMP (F):94
CONDITION:SUNNY & HUMID

VEHICLE: JEEP HONCHO
AXLES: 2
BLOCKS: 1 STEEL
DRIVER: 175, lb
TIRE PRES.: 48 PSI

EAST WGT:5160 lb
WEST WGT:5160 lb
AVG. WGT:5160 lb

| RUN: | AXLES' WEIGHT, lb 1 | 2 | TOTAL WEIGHT | ERROR |
|---|---|---|---|---|
| 1 | 2400 | 2800 | 5200 | 0.0078 |
| 2 | 2420 | 2780 | 5200 | 0.0078 |
| 3 | 2400 | 2800 | 5200 | 0.0078 |
| 4 | 2380 | 2800 | 5180 | 0.0039 |
| 5 | 2400 | 2800 | 5200 | 0.0078 |
| 6 | 2400 | 2800 | 5200 | 0.0078 |
| 7 | 2420 | 2800 | 5220 | 0.0116 |
| 8 | 2420 | 2800 | 5220 | 0.0116 |
| 9 | 2420 | 2800 | 5220 | 0.0116 |
| 10 | 2400 | 2800 | 5200 | 0.0078 |
| 11 | 2400 | 2800 | 5200 | 0.0078 |
| 13 | 2400 | 2780 | 5180 | 0.0039 |
| 14 | 2400 | 2800 | 5200 | 0.0078 |
| 15 | 2420 | 2820 | 5240 | 0.0155 |
| 16 | 2420 | 2820 | 5240 | 0.0155 |
| 17 | 2420 | 2820 | 5240 | 0.0155 |
| 18 | 2400 | 2820 | 5220 | 0.0116 |
| 19 | 2420 | 2820 | 5240 | 0.0155 |
| 20 | 2420 | 2820 | 5240 | 0.0155 |
| 21 | 2400 | 2840 | 5240 | 0.0155 |
| 22 | 2440 | 2800 | 5240 | 0.0155 |
| 23 | 2380 | 2800 | 5180 | 0.0039 |
| 24 | 2380 | 2800 | 5180 | 0.0039 |
| 25 | 2380 | 2780 | 5160 | 0.0000 |
| 26 | 2400 | 2760 | 5160 | 0.0000 |
| 27 | 2380 | 2780 | 5160 | 0.0000 |
| 28 | 2400 | 2780 | 5180 | 0.0039 |
| 29 | 2400 | 2780 | 5180 | 0.0039 |
| 30 | 2380 | 2780 | 5160 | 0.0000 |
| Max. | 2440 | 2840 | 5240 | |
| Min. | 2380 | 2760 | 5160 | |

| | | |
|---|---|---|
| TOTAL | 156080 | 0.2481 |
| MEAN | 5202.667 | 0.0083 |
| STANDARD | 27.156 | 0.0053 |
| VARIANCE | 737.471 | 0.0000 |
| COVARIANCE | 0.522 | 63.6479 |
| % ERROR | 0.827 | |

## P.A.T. SCALE DATA: JEEP HONCHO (Half-load)

DATE:06/24/92
TIME:03:05 PM
TEMP (F):112
CONDITION:EXTREME HEAT

VEHICLE: JEEP HONCHO
AXLES: 2
BLOCKS: EMPTY
DRIVER: 175, lb
TIRE PRESS.: 49.5 PSI
AVG. WEIGHT: 4170 lb

EAST WGT:4160 lb
WEST WGT:4180 lb

| AXLES' WEIGHT, lb RUN: | 1 | 2 | TOTAL WEIGHT | ERROR |
|---|---|---|---|---|
| 1 | 2400 | 1760 | 4160 | -0.0024 |
| 2 | 2380 | 1780 | 4160 | -0.0024 |
| 3 | 2380 | 1780 | 4160 | -0.0024 |
| 4 | 2400 | 1780 | 4180 | 0.0024 |
| 5 | 2380 | 1780 | 4160 | -0.0024 |
| 6 | 2380 | 1780 | 4160 | -0.0024 |
| 7 | 2380 | 1760 | 4140 | -0.0072 |
| 8 | 2400 | 1780 | 4180 | 0.0024 |
| 9 | 2380 | 1780 | 4160 | -0.0024 |
| 10 | 2380 | 1780 | 4160 | -0.0024 |
| 11 | 2400 | 1780 | 4180 | 0.0024 |
| 12 | 2400 | 1780 | 4180 | 0.0024 |
| 13 | 2400 | 1780 | 4180 | 0.0024 |
| 14 | 2400 | 1780 | 4180 | 0.0024 |
| 15 | 2400 | 1800 | 4200 | 0.0072 |
| 16 | 2400 | 1780 | 4180 | 0.0024 |
| 17 | 2400 | 1780 | 4180 | 0.0024 |
| 18 | 2400 | 1780 | 4180 | 0.0024 |
| 19 | 2420 | 1800 | 4220 | 0.0120 |
| 20 | 2400 | 1780 | 4180 | 0.0024 |
| 21 | 2380 | 1780 | 4160 | -0.0024 |
| 22 | 2380 | 1780 | 4160 | -0.0024 |
| 23 | 2400 | 1760 | 4160 | -0.0024 |
| 24 | 2380 | 1760 | 4140 | -0.0072 |
| 25 | 2380 | 1780 | 4160 | -0.0024 |
| 26 | 2400 | 1780 | 4180 | 0.0024 |
| 27 | 2420 | 1780 | 4200 | 0.0072 |
| 28 | 2400 | 1780 | 4180 | 0.0024 |
| 29 | 2400 | 1780 | 4180 | 0.0024 |
| 30 | 2380 | 1780 | 4160 | -0.0024 |
| Max. | 2420 | 1800 | 4220 | |
| Min. | 2380 | 1760 | 4140 | |

| | | |
|---|---|---|
| TOTAL | 125160 | 0.0144 |
| MEAN | 4172 | 0.0005 |
| STANDARD | 17.100 | 0.0041 |
| VARIANCE | 292.414 | 0.0000 |
| COVARIANCE | 0.410 | 855.0055 |
| % ERROR | 0.048 | |

**TEST #1**

**Jeep with load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = 8.60551351

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**Jeep empty**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30
6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = 0.64060702

7. Conclusion: Accept Ho at 0.05 level of significance. There are not significant differences between the sample and population mean

**TEST #2: Cochran's test**

1. Ho: The variances of the load and unload samples are equal
2. H1: The variances of the load and unload samples are not equal

3. alpha = 0.05
4. Critical Region: G = 0.686065

| | |
|---|---|
| 17 | 0.7341 |
| 30 | x |
| 37 | 0.6602 |
| x = | 54.8852 |

5. Computations:

| | | |
|---|---|---|
| S load^2 = | 737.471264 | |
| S unload^2 = | 292.413793 | |
| S total = | 1029.88506 | |
| g = | 0.71607143 | > G then, |

6. Conclusion: Reject Ho at 0.05 level of significance. There is a significant differences between the load and unload samples' variance

**TEST #3: ANOVA**

1. Ho: The load and the unload samples' mean are equal

2. H1: The load and the unload samples' mean are not equal

3. alpha = 0.05
4. Degrees of freedom
   nu 1 = # samples - 1 = 1
   nu 2 = # samples(sample size - 1) = 58

5. Critical region: F > 4.008

| | |
|---|---|
| 40 | 4.08 |
| 58 | x |
| 60 | 4 |
| x = | 4.008 |

6. Computations:

| Source of variation | Sum of Squares | Degree of Freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Aggregates | 15934106.7 | 1 | 15934106.7 | 30943.5 > F then, |
| Error | 29866.7 | 58 | 514.9 | |
| Total | 15963973.3 | 59 | | |

7. Conclusion: Reject Ho and conclude that the samples do not have the same mean

## P.A.T. SCALE DATA: 3S2/BLUE TRACTOR (Load)

DATE:06/24/92
TIME:07:37 AM
TEMP (F):99
CONDITION:SUNNY & HUMID

VEHICLE: 3S2/BLUE TRACTOR
AXLES: 5
BLOCKS: 16 LEAD
DRIVER: 215, lb
TIRE PRESS.: 85 PSI
AVG. WEIGHT:69260 lb

EAST WGHT:69320 lb
WEST WGHT:69200 lb

| | AXLES' WEIGHT, lb | | | | | TOTAL | |
|---|---|---|---|---|---|---|---|
| RUN: | 1 | 2 | 3 | 4 | 5 | WEIGHT | ERROR |
| 1 | 9320 | 13920 | 13480 | 16160 | 16480 | 69360 | 0.0014 |
| 2 | 9760 | 13400 | 13500 | 16260 | 16040 | 68960 | -0.0043 |
| 3 | 9580 | 14520 | 13880 | 16240 | 16340 | 70560 | 0.0188 |
| 4 | 9920 | 13560 | 13980 | 16120 | 16300 | 69880 | 0.0090 |
| 5 | 9200 | 14020 | 13420 | 16200 | 16220 | 69060 | -0.0029 |
| 6 | 9620 | 13660 | 13740 | 16280 | 16320 | 69620 | 0.0052 |
| 7 | 9740 | 14580 | 13720 | 16260 | 16240 | 70540 | 0.0185 |
| 8 | 9780 | 14080 | 13520 | 16120 | 16240 | 69740 | 0.0069 |
| 9 | 9760 | 13700 | 13500 | 16160 | 16360 | 69480 | 0.0032 |
| 10 | 9760 | 13980 | 13700 | 16260 | 16280 | 69980 | 0.0104 |
| 11 | 9720 | 13960 | 13660 | 16280 | 16180 | 69800 | 0.0078 |
| 12 | 9460 | 14000 | 13840 | 16260 | 16280 | 69840 | 0.0084 |
| 13 | 9540 | 13820 | 13760 | 16140 | 16380 | 69640 | 0.0055 |
| 14 | 9840 | 13680 | 13760 | 16120 | 16280 | 69680 | 0.0061 |
| 15 | 9640 | 13860 | 13760 | 16220 | 16200 | 69680 | 0.0061 |
| 16 | 9520 | 13980 | 13840 | 16180 | 16240 | 69760 | 0.0072 |
| 17 | 9640 | 13940 | 13460 | 16160 | 16200 | 69400 | 0.0020 |
| 18 | 9520 | 14020 | 13660 | 16220 | 16340 | 69760 | 0.0072 |
| 19 | 9800 | 13840 | 13600 | 16180 | 16360 | 69780 | 0.0075 |
| 20 | 9440 | 14360 | 13640 | 15940 | 16200 | 69580 | 0.0046 |
| 21 | 9720 | 13740 | 13760 | 15980 | 15980 | 69180 | -0.0012 |
| 22 | 9720 | 14420 | 13780 | 15920 | 15920 | 69760 | 0.0072 |
| 23 | 9720 | 13300 | 13940 | 16180 | 16240 | 69380 | 0.0017 |
| 24 | 9780 | 13880 | 13580 | 16280 | 16180 | 69700 | 0.0064 |
| 25 | 9640 | 13720 | 13800 | 16180 | 16280 | 69620 | 0.0052 |
| 26 | 9740 | 13660 | 13960 | 16120 | 16320 | 69800 | 0.0078 |
| 27 | 9820 | 13820 | 13900 | 16180 | 16160 | 69880 | 0.0090 |
| 28 | 9580 | 13640 | 13820 | 16020 | 16280 | 69340 | 0.0012 |
| 29 | 9600 | 14160 | 13640 | 16280 | 16380 | 70060 | 0.0116 |
| 30 | 9620 | 13920 | 13820 | 16380 | 16180 | 69920 | 0.0095 |
| Max. | 9920 | 14580 | 13980 | 16380 | 16480 | 70560 | |
| Min. | 9200 | 13300 | 13420 | 15920 | 15920 | 68960 | |

| | | |
|---|---|---|
| TOTAL | 2090740 | 0.1868 |
| MEAN | 69691.333 | 0.0062 |
| STANDARD | 350.75026 | 0.0051 |
| VARIANCE | 123025.75 | 0.0000 |
| COVARIANCE | 0.503 | 81.3177 |
| % ERROR | 0.623 | |

**P.A.T. SCALE DATA: 3S2/BLUE TRACTOR (Half-load)**

DATE:06/25/92
TIME:08:48 AM
TEMP (F):100
CONDITION:SUNNY & HUMID

EAST WGHT:52860 lb
WEST WGHT:52860 lb

VEHICLE:3S2/BLUE TRACTOR
AXLES: 5
BLOCKS: 8 LEAD
DRIVER: 210, lb
TIRE PRESS.: 90 PSI
AVG. WEIGHT:52860 lb

| | AXLES' WEIGHT, lb | | | | | TOTAL | |
|---|---|---|---|---|---|---|---|
| RUN: | 1 | 2 | 3 | 4 | 5 | WEIGHT | ERROR |
| 1 | 9800 | 10760 | 11180 | 10580 | 11000 | 53320 | 0.0087 |
| 2 | 9780 | 10740 | 11100 | 10600 | 10840 | 53060 | 0.0038 |
| 3 | 9700 | 10920 | 10900 | 10820 | 10800 | 53140 | 0.0053 |
| 4 | 9580 | 10800 | 11020 | 10800 | 10800 | 53000 | 0.0026 |
| 5 | 9760 | 10680 | 10940 | 10780 | 10820 | 52980 | 0.0023 |
| 6 | 9760 | 10880 | 11000 | 10760 | 10720 | 53120 | 0.0049 |
| 7 | 9860 | 10800 | 10740 | 10760 | 10780 | 52940 | 0.0015 |
| 8 | 9560 | 10880 | 11280 | 10640 | 10980 | 53340 | 0.0091 |
| 9 | 9560 | 11060 | 10740 | 10680 | 10920 | 52960 | 0.0019 |
| 10 | 9800 | 10560 | 11300 | 10760 | 10940 | 53360 | 0.0095 |
| 11 | 9640 | 10820 | 10720 | 10700 | 10920 | 52800 | -0.0011 |
| 12 | 9560 | 10980 | 10880 | 10740 | 10860 | 53020 | 0.0030 |
| 13 | 9580 | 10900 | 10720 | 10780 | 10880 | 52860 | 0.0000 |
| 14 | 9640 | 10980 | 10860 | 10820 | 10780 | 53080 | 0.0042 |
| 15 | 9760 | 11020 | 11040 | 10760 | 10880 | 53460 | 0.0114 |
| 16 | 9660 | 10880 | 10780 | 10660 | 10840 | 52820 | -0.0008 |
| 17 | 9580 | 10580 | 10820 | 10720 | 10840 | 52540 | -0.0061 |
| 18 | 9620 | 11080 | 10820 | 10660 | 10780 | 52960 | 0.0019 |
| 19 | 9720 | 11100 | 11060 | 10700 | 11080 | 53660 | 0.0151 |
| 20 | 9860 | 10840 | 10820 | 10780 | 10920 | 53220 | 0.0068 |
| 21 | 9780 | 10800 | 10980 | 11060 | 10880 | 53500 | 0.0121 |
| 22 | 9880 | 10840 | 10940 | 10760 | 10860 | 53280 | 0.0079 |
| 23 | 9900 | 10760 | 10900 | 10800 | 10780 | 53140 | 0.0053 |
| 24 | 9820 | 10960 | 10820 | 10780 | 10920 | 53300 | 0.0083 |
| 25 | 9820 | 10800 | 10840 | 10720 | 10980 | 53160 | 0.0057 |
| 26 | 9800 | 10900 | 10800 | 10880 | 10880 | 53260 | 0.0076 |
| 27 | 9640 | 10920 | 10900 | 10880 | 10860 | 53200 | 0.0064 |
| 28 | 9820 | 10900 | 10800 | 10680 | 10880 | 53080 | 0.0042 |
| 29 | 9840 | 11040 | 10620 | 10660 | 11060 | 53220 | 0.0068 |
| 30 | 9800 | 11320 | 10660 | 10680 | 10800 | 53260 | 0.0076 |
| Max. | 9900 | 11320 | 11300 | 11060 | 11080 | 53660 | |
| Min. | 9560 | 10560 | 10620 | 10580 | 10720 | 52540 | |

| | | |
|---|---|---|
| TOTAL | 1594040 | 0.1559 |
| MEAN | 53134.667 | 0.0052 |
| STANDARD | 231.03565 | 0.0044 |
| VARIANCE | 53377.471 | 0.0000 |
| COVARIANCE | 0.435 | 84.1149 |
| % ERROR | 0.520 | |

**TEST #1**

**3S2 truck load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30

6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = 6.73559

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population mean

**3S2 truck half load**

1. Ho: The sample mean is equal to the population mean

2. H1: The sample mean is not equal to the population mean

3. alpha = 0.05
4. Critical Region: - Z(alpha/2) = -1.96,
   Z(alpha/2) = 1.96
5. Number of observations (runs): n = 30

6. Computations:
   z =(Sample mean - Population mean)/(standard deviation/sqrt(n)) = 6.5115981

7. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the sample and population variance

**TEST #2: Cochran's test**

1. Ho: The variances of the load and unload samples are equal

2. H1: The variances of the load and unload samples are not equal
3. alpha = 0.05
4. Critical Region: G = 0.686065

| | |
|---|---|
| 17 | 0.7341 |
| 30 | x |
| 37 | 0.6602 |
| x = | 43.90816 |

5. Computations:

S load^2 = 123025.75
S unload^2 = 53377.471
S total = 176403.22
g = 0.6974121 > G then,

6. Conclusion: Reject Ho at 0.05 level of significance. There is a significant difference between the load and unload samples' variance

**TEST #3: ANOVA**

1. Ho: The load and the unload samples' mean are equal

2. H1: The load and the unload samples' mean are not equal

3. alpha = 0.05
4. Degrees of freedom
   nu 1 = # samples - 1 = 1
   nu 2 = # samples(sample size - 1) = 58

5. Critical region: F > 4.008

| | |
|---|---|
| 40 | 4.08 |
| 58 | x |
| 60 | 4 |
| x = | 4.008 |

6. Computations:

| Source of variation | Sum of Squares | Degree of Freedom | Mean Square | Computed f |
|---|---|---|---|---|
| Aggregates | 4.11E+09 | 1 | 4111848166.7 | 46618.7> F then, |
| Error | 5115693.3 | 58 | 88201.609195 | |
| Total | 4.117E+09 | 59 | | |

7. Conclusion: Reject Ho and conclude that the samples do not have the same mean

## APPENDIX D

## DIFFERENCE BETWEEN THE MEASURED AND TRUE WEIGHT

Equation D.1 shows how the difference between the true and the measured weight was calculated. These differences can be used to evaluate the PAT accuracy. For each vehicle measure, the mean, standard deviation, and variance were calculated. The number of runs was calculated using the standard deviation of the difference and the percent of accuracy desired.

$$Difference = \frac{Measure\ weight - True\ weight}{True\ weight} \tag{D.1}$$

| LOAD | JEEP | AT6X6 | GMC | GMCS | T3S2 |
|---|---|---|---|---|---|
| | 0.0078 | 0.0025 | -0.0051 | -0.0053 | 0.0014 |
| | 0.0078 | 0.0086 | -0.0108 | -0.0093 | - 0.0043 |
| | 0.0078 | 0.0074 | -0.0009 | -0.0155 | 0.0188 |
| | 0.0039 | 0.0029 | -0.0075 | -0.0182 | 0.0090 |
| | 0.0078 | -0.0046 | -0.0043 | -0.0122 | - 0.0029 |
| | 0.0078 | 0.0091 | -0.0001 | -0.0182 | 0.0052 |
| | 0.0116 | 0.0108 | -0.0033 | -0.0135 | 0.0185 |
| | 0.0116 | -0.0017 | -0.0100 | -0.0103 | 0.0069 |
| | 0.0116 | 0.0160 | -0.0053 | -0.0189 | 0.0032 |
| | 0.0078 | 0.0188 | -0.0066 | -0.0125 | 0.0104 |
| | 0.0078 | 0.0120 | -0.0098 | -0.0112 | 0.0078 |
| | 0.0078 | 0.0057 | -0.0083 | -0.0140 | 0.0084 |
| | 0.0039 | 0.0046 | -0.0041 | -0.0135 | 0.0055 |
| | 0.0078 | 0.0086 | -0.0125 | -0.0167 | 0.0061 |
| | 0.0155 | 0.0114 | -0.0103 | -0.0197 | 0.0061 |
| | 0.0155 | 0.0131 | -0.0105 | | 0.0072 |
| | 0.0155 | 0.0125 | -0.0031 | | 0.0020 |
| | 0.0116 | 0.0011 | -0.0046 | | 0.0072 |
| | 0.0155 | 0.0057 | -0.0152 | | 0.0075 |
| | 0.0155 | 0.0034 | -0.0058 | | 0.0046 |
| | 0.0155 | 0.0068 | -0.0122 | | - 0.0012 |
| | 0.0155 | 0.0046 | -0.0093 | | 0.0072 |
| | 0.0039 | 0.0120 | -0.0058 | | 0.0017 |
| | 0.0039 | 0.0148 | -0.0145 | | 0.0064 |
| | 0.0000 | 0.0029 | -0.0127 | | 0.0052 |
| | 0.0000 | 0.0125 | -0.0075 | | 0.0078 |
| | 0.0000 | -0.0029 | -0.0070 | | 0.0090 |
| | 0.0039 | 0.0086 | -0.0083 | | 0.0012 |
| | 0.0039 | 0.0017 | -0.0073 | | 0.0116 |
| | 0.0000 | 0.0034 | -0.0083 | | 0.0095 |
| MEAN | 0.0083 | 0.0071 | -0.0077 | -0.0139 | 0.0062 |
| STND | 0.0053 | 0.0057 | 0.0038 | 0.0040 | 0.0051 |
| VAR | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| Accuracy | Number of runs | | | | |
|---|---|---|---|---|---|
| 1 | 1.0640 | 1.2461 | 0.5407 | 0.6187 | 0.9852 |
| 2 | 0.2660 | 0.3115 | 0.1352 | 0.1547 | 0.2463 |
| 3 | 0.1182 | 0.1385 | 0.0601 | 0.0687 | 0.1095 |

UNLOAD

| | JEEP | AT6X6 | GMC | GMCS | 3S2 |
|---|---|---|---|---|---|
| | -0.0024 | -0.0033 | -0.0009 | -0.0133 | 0.0087 |
| | -0.0024 | -0.0092 | -0.0022 | -0.0127 | 0.0038 |
| | -0.0024 | -0.0122 | -0.0040 | -0.0108 | 0.0053 |
| | 0.0024 | -0.0077 | -0.0053 | -0.0124 | 0.0026 |
| | -0.0024 | -0.0077 | -0.0019 | -0.0176 | 0.0023 |
| | -0.0024 | -0.0077 | -0.0049 | -0.0142 | 0.0049 |
| | -0.0072 | -0.0048 | -0.0043 | -0.0130 | 0.0015 |
| | 0.0024 | 0.0004 | -0.0059 | -0.0102 | 0.0091 |
| | -0.0024 | 0.0018 | -0.0031 | -0.0127 | 0.0019 |
| | -0.0024 | -0.0018 | -0.0025 | -0.0096 | 0.0095 |
| | 0.0024 | -0.0018 | -0.0046 | -0.0093 | - 0.0011 |
| | 0.0024 | 0.0063 | -0.0028 | -0.0133 | 0.0030 |
| | 0.0024 | 0.0055 | -0.0049 | -0.0111 | 0.0000 |
| | 0.0024 | -0.0011 | -0.0028 | -0.0111 | 0.0042 |
| | 0.0072 | 0.0011 | -0.0053 | -0.0117 | 0.0114 |
| | 0.0024 | 0.0004 | -0.0040 | | - 0.0008 |
| | 0.0024 | -0.0004 | -0.0019 | | - 0.0061 |
| | 0.0024 | -0.0055 | -0.0077 | | 0.0019 |
| | 0.0120 | 0.0026 | -0.0031 | | 0.0151 |
| | 0.0024 | 0.0026 | -0.0046 | | 0.0068 |
| | -0.0024 | 0.0004 | -0.0031 | | 0.0121 |
| | -0.0024 | 0.0041 | -0.0056 | | 0.0079 |
| | -0.0024 | 0.0026 | -0.0074 | | 0.0053 |
| | -0.0072 | 0.0033 | -0.0068 | | 0.0083 |
| | -0.0024 | 0.0011 | -0.0062 | | 0.0057 |
| | 0.0024 | 0.0018 | -0.0071 | | 0.0076 |
| | 0.0072 | 0.0048 | -0.0049 | | 0.0064 |
| | 0.0024 | 0.0004 | -0.0043 | | 0.0042 |
| | 0.0024 | 0.0099 | -0.0043 | | 0.0068 |
| | -0.0024 | 0.0144 | -0.0059 | | 0.0076 |
| MEAN | 0.0005 | -0.0000 | -0.0044 | -0.0122 | 0.0052 |
| STND | 0.0041 | 0.0057 | 0.0018 | 0.0021 | 0.0044 |
| VAR | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| Accuracy | | Number of runs | | | |
|---|---|---|---|---|---|
| 1 | 0.6460 | 1.2447 | 0.1180 | 0.1667 | 0.7339 |
| 2 | 0.1615 | 0.3112 | 0.0295 | 0.0417 | 0.1835 |
| 3 | 0.0718 | 0.1383 | 0.0131 | 0.0185 | 0.0815 |

APPENDIX E

NUMBER OF RUNS REQUIRED TO REPLICATE THE WEIGHING CONDITIONS

The number of runs for confidence level of 95 percent was calculated using Equation 2.1. The vehicles weight are expressed in pounds.

**ACCURACY OF 1%**

Z = 1.96 ERROR 0.01

**LOAD**

| TYPE OF VEHICLE | EAST WEIGHT | WEST WEIGHT | AVERAGE WEIGHT | SAMPLE WEIGHT | STAND. DESV. | N |
|---|---|---|---|---|---|---|
| Jeep | 5160 | 5160 | 5160 | 5202.67 | 27.16 | 1.06 |
| 3S2 | 69320 | 69200 | 69260 | 69691.33 | 350.75 | 0.99 |
| GMC | 80920 | 80860 | 80890 | 80267.33 | 303.47 | 0.54 |
| GMCS | 80920 | 80860 | 80890 | 79764.00 | 324.63 | 0.62 |
| AT6X6 | 35060 | 35060 | 35060 | 35308.27 | 199.68 | 1.25 |

**UNLOAD**

| TYPE OF VEHICLE | EAST WEIGHT | WEST WEIGHT | AVERAGE WEIGHT | SAMPLE WEIGHT | STAND. DESV. | N |
|---|---|---|---|---|---|---|
| Jeep | 4180 | 4160 | 4170 | 4172.00 | 17.10 | 0.65 |
| 3S2 | 52860 | 52860 | 52860 | 53134.67 | 231.04 | 0.73 |
| GMC | 64720 | 64680 | 64700 | 64414.67 | 113.37 | 0.12 |
| GMCS | 64720 | 64680 | 64700 | 63910.67 | 134.77 | 0.17 |
| AT6X6 | 27160 | 27140 | 27150 | 21150.00 | 154.54 | 1.24 |

**ACCURACY OF 2%**

Z 1.96 ERROR 0.02

**LOAD**

| TYPE OF VEHICLE | EAST WEIGHT | WEST WEIGHT | AVERAGE WEIGHT | SAMPLE WEIGHT | STAND. DESV. | N |
|---|---|---|---|---|---|---|
| Jeep | 5160 | 5160 | 5160 | 5202.67 | 27.16 | 0.27 |
| 3S2 | 69320 | 69200 | 69260 | 69691.33 | 350.75 | 0.25 |
| GMC | 80920 | 80860 | 80890 | 80267.33 | 303.47 | 0.14 |
| GMCS | 80920 | 80860 | 80890 | 79764.00 | 324.63 | 0.15 |
| AT6X6 | 35060 | 35060 | 35060 | 35308.27 | 199.68 | 0.31 |

**UNLOAD**

| TYPE OF VEHICLE | EAST WEIGHT | WEST WEIGHT | AVERAGE WEIGHT | SAMPLE WEIGHT | STAND. DESV. | N |
|---|---|---|---|---|---|---|
| Jeep | 4180 | 4160 | 4170 | 4172.00 | 17.10 | 0.16 |
| 3S2 | 52860 | 52860 | 52860 | 53134.67 | 231.04 | 0.18 |
| GMC | 64720 | 64680 | 64700 | 64081.33 | 1832.02 | 7.70 |
| GMCS | 64720 | 64680 | 64700 | 63910.67 | 134.77 | 0.04 |
| AT6X6 | 27160 | 27140 | 27150 | 21150.00 | 154.54 | 0.31 |

**ACCURACY OF 3%**

Z = 1.96 ERROR 0.03

**LOAD**

| TYPE OF VEHICLE | EAST WEIGHT | WEST WEIGHT | AVERAGE WEIGHT | SAMPLE WEIGHT | STAND. DESV. | N |
|---|---|---|---|---|---|---|
| Jeep | 5160 | 5160 | 5160 | 5202.67 | 27.16 | 0.12 |
| 3S2 | 69320 | 69200 | 69260 | 69691.33 | 350.75 | 0.11 |
| GMC | 80920 | 80860 | 80890 | 80267.33 | 303.47 | 0.06 |
| GMCS | 80920 | 80860 | 80890 | 79764.00 | 324.63 | 0.07 |
| AT6X6 | 35060 | 35060 | 35060 | 35308.27 | 199.68 | 0.14 |

**UNLOAD**

| TYPE OF VEHICLE | EAST WEIGHT | WEST WEIGHT | AVERAGE WEIGHT | SAMPLE WEIGHT | STAND. DESV. | N |
|---|---|---|---|---|---|---|
| Jeep | 4180 | 4160 | 4170 | 4172.00 | 17.10 | 0.07 |
| 3S2 | 52860 | 52860 | 52860 | 53134.67 | 231.04 | 0.08 |
| GMC | 64720 | 64680 | 64700 | 64081.33 | 1832.02 | 3.42 |
| GMCS | 64720 | 64680 | 64700 | 63910.67 | 134.77 | 0.02 |
| AT6X6 | 27160 | 27140 | 27150 | 21150.00 | 154.54 | 0.14 |

APPENDIX F

PAT CONFIDENCE INTERVALS

The confidence intervals were calculated using Equation 5.1.

ACCURACY OF 1%
Z 1.96 ERROR 0.01

**LOAD**

| | CONFIDENCE INTERVAL | | | | RANGE | |
|---|---|---|---|---|---|---|
| | MEAN | | VARIANCE | | MEAN | VARIANCE |
| Jeep | 5192.9 | 5212.4 | 1124.2 | 7920.7 | 19.4 | 6796.5 |
| 3S2 | 69565.8 | 69816.8 | 187549.2 | 1321387.9 | 251.0 | 1133838.8 |
| GMC | 80158.7 | 80375.9 | 140397.8 | 989180.4 | 217.2 | 848782.6 |
| GMCs | 79647.8 | 79880.2 | 160653.1 | 1131890.2 | 232.3 | 971237.2 |
| AT6X6 | 35236.8 | 35379.7 | 60781.9 | 428242.2 | 142.9 | 367460.3 |

**UNLOAD**

| | CONFIDENCE INTERVAL | | | | RANGE | |
|---|---|---|---|---|---|---|
| | MEAN | | VARIANCE | | MEAN | VARIANCE |
| Jeep | 4165.9 | 4178.1 | 445.8 | 3140.7 | 12.2 | 2694.9 |
| 3S2 | 53051.9 | 53217.3 | 81372.6 | 573315.3 | 165.4 | 491942.7 |
| GMC | 63425.8 | 64736.9 | 5116581.4 | 36049158 | 1311.2 | 30932577.0 |
| GMCs | 63862.4 | 63958.9 | 27690.2 | 195092.8 | 96.5 | 167402.6 |
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